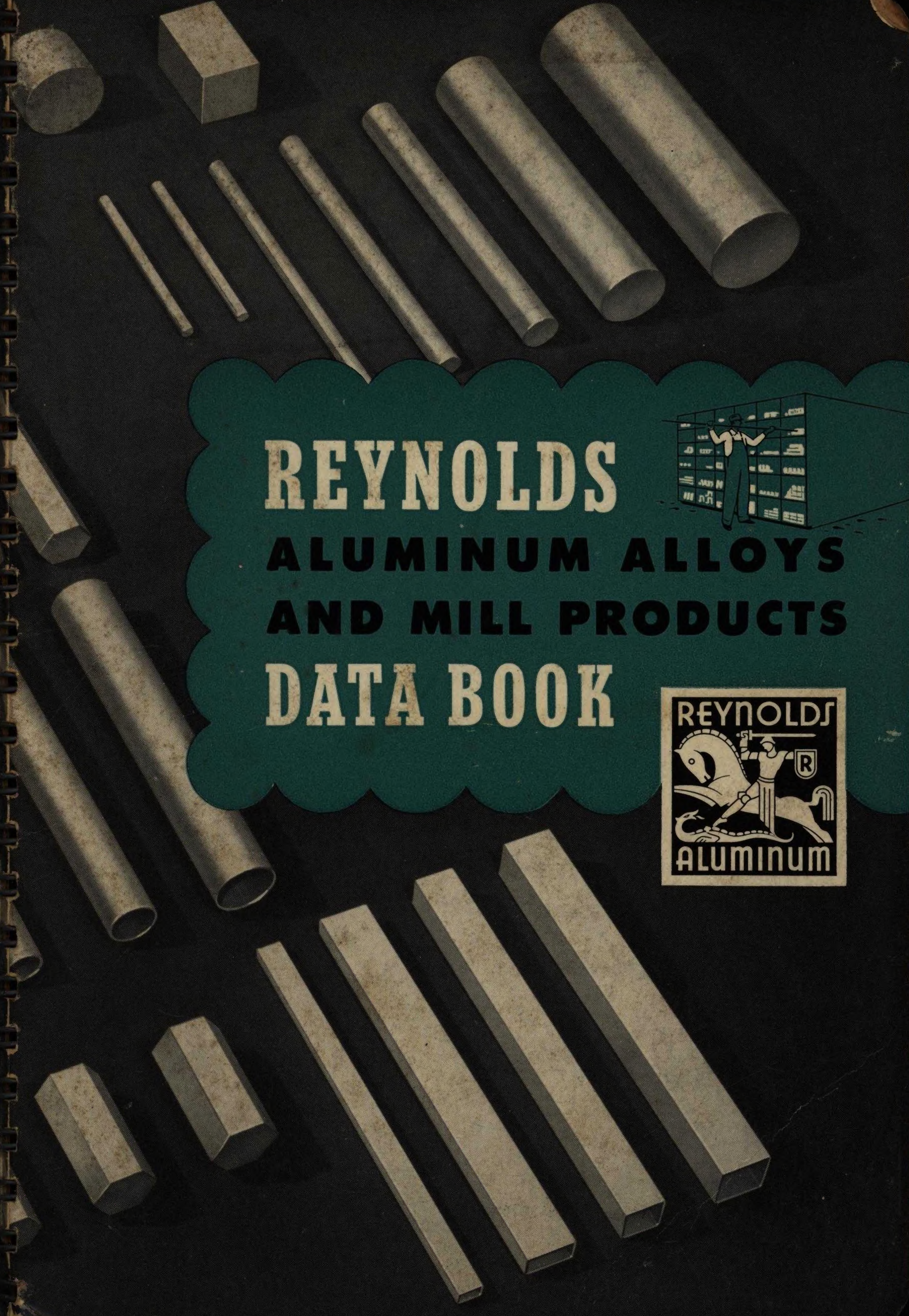

REYNOLDS

ALUMINUM ALLOYS AND MILL PRODUCTS

DATA BOOK

REYNOLDS

ALUMINUM

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REYNOLDS ALUMINUM ALLOYS and MILL PRODUCTS

REYNOLDS METALS COMPANY
INCORPORATED
LOUISVILLE 1, KENTUCKY

PRICE $2.00

foreword: This book describes aluminum alloys and aluminum mill products made by Reynolds Metals Company. Since there are many different alloys from which to choose, the user needs rather definite information about them in order to make an intelligent selection. This book represents an endeavor to furnish such information.

In many cases, the range of sizes shown can be exceeded, since the rapid developments in the aluminum industry are being accompanied by continually putting new mills and additional plant facilities into production. So we suggest the prospective user contact his Reynolds field representative (page 248) whenever his requirements fall outside the standards listed here.

From the Table of Contents, page 7, it will be seen that the information in this book is arranged according to mill products — sheet and plate; extruded shapes; roll formed shapes; tubing and pipe; wire, rod and bar; forging stock; press forgings; ingot metal for sand casting, permanent mold casting, and die casting. It covers range of sizes, chemical compositions, yield and ultimate strengths, hardnesses, tolerances and the like.

Since this is the first printing of this data book, there may be errors of omission and commission. Readers are invited to send in corrections and suggestions for making this booklet more useful. Address Editorial Department, Reynolds Metals Company, 2500 South Third St., Louisville 1, Ky.

free enterprise in ALUMINUM

The war transformed aluminum from a metal of scarcity and limited utility to a metal of abundance and extreme usefulness. The part the Reynolds Metals Company, the nation's largest foil producer, played in this transformation is one of the sagas of modern business.

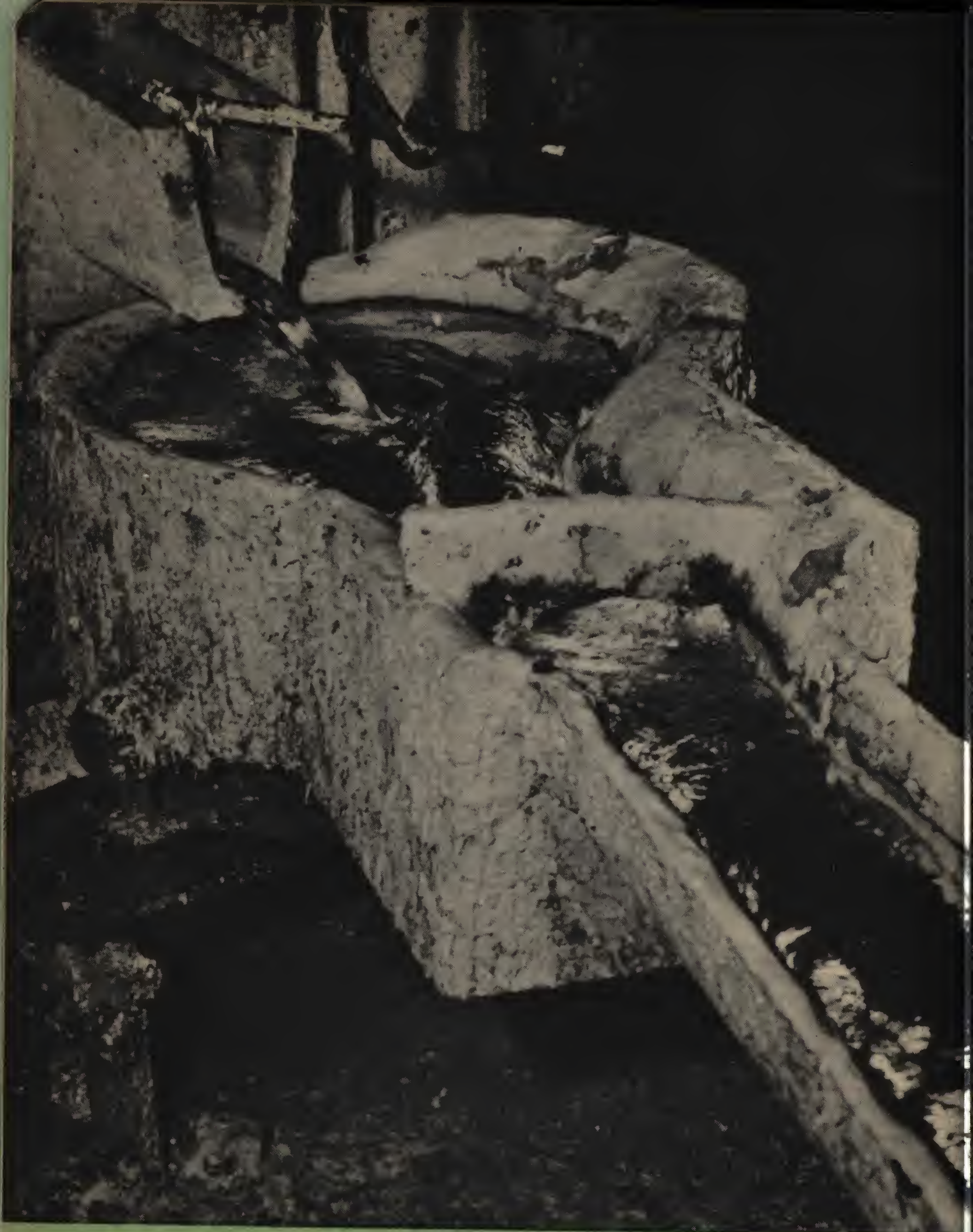
In 1939 the company president, Mr. R. S. Reynolds, foresaw our involvement in a light metals war and advocated large increases in the nation's aluminum capacity. In 1940 this company, entirely on its own, undertook the building of large new aluminum production facilities.

Today the Reynolds Metals Company is sweeping forward as the nation's great new source of aluminum in all its forms. Here is a company that has proven, during these critical war years, what an alert, vigorous and forward-looking organization can do. Let us demonstrate what Reynolds initiative and all-out tradition-free effort can do for you through our service offices distributed throughout Industrial America, listed on page 248.

The color flag appearing at the upper right of this page is used throughout this book as a ready reference guide to aid in quickly locating the various sections. The key to the colors used will be found below, with the section name and page number:

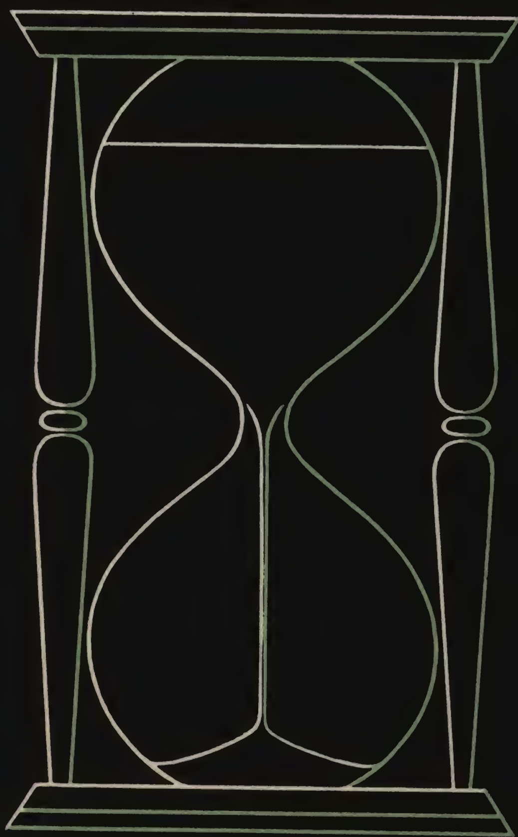
Pot room at Reynolds Longview, Wash., plant. Operator is stirring alumina into the bath where it is reduced to molten aluminum

contents



Molten aluminum alloy metal being tapped from a remelting furnace at a Reynolds extrusion plant. Here pure aluminum pig has been melted and alloying elements added to strengthen the metal

1 • history



Precipitation tank at Reynolds Listerhill plant, seen at night

The use of metals dates far back to the recesses of history. Many centuries before the year 1 A.D., man used heavy metal in making weapons, cooking pots, implements for working the soil, and other various tools to help him live in his crude environment. Since that time many metals and combinations of metals have taken their places to aid in the advancement of civilization.

hans christian oersted

Slightly more than a hundred years ago, a Danish scientist, Hans Christian Oersted, isolated a new metal — aluminum. Prior to this time, aluminum was known to exist only in strong chemical combination with other elements. By heating a mixture of aluminum chloride and potassium amalgam, Oersted was able to obtain a small amount of pure aluminum. However, this experiment, which first produced aluminum in 1825, failed to produce aluminum when repeated two years later by Friedrich Wohler. Wohler then performed a similar experiment in which metallic potassium was used in place of the amalgam and obtained a sufficient amount of aluminum to permit investigation of its qualities and characteristics. Thus, he was the first to discover the lightness of aluminum — the quality for which it first received acceptance in a wide variety of applications.

henri sainte-claire deville

Although these early experiments did serve to provide some information about aluminum, none of them was practicable as an economical method for quality production. Much work was yet to be done before the metal could be produced for the many commercial uses in which we know it today — much work which might have been delayed had not Napoleon III seen in aluminum a metal from which to make lighter, more easily transported equipment for his armies. He wanted great quantities of aluminum — enough to equip France's standing army — manufactured by a cheap method to avoid greatly increasing the national debt. Henri Sainte-Claire Deville was commissioned by Napoleon to find the key to cheap aluminum — to make a common metal out of a precious metal.

In 1852, aluminum had long been quoted at $542 a pound, but Deville was working constantly to reduce this prohibitive price and in the following four years the price dropped to $34 a pound. In the next three years that price was halved, but it was still too expensive

Cast house at Reynolds Listerhill plant, America's first independent-owned straight-line-production ore-to-sheet aluminum plant

for Napoleon's purpose. Aluminum bars produced by Deville were exhibited at the Paris Exposition in 1855 and one year later commercial production was started at Glaciere, a suburb of Paris. In 1859, at $17 a pound, the total world's production of aluminum was but two tons!

Aluminum was still a precious metal and the small commercial production was justified only by its novelty. It was toyed with by the wealthy as ornaments and jewelry and even aluminum forks and spoons fed the royalty in preference to gold and silver.

Deville had improved upon the Wohler process, substituting sodium for potassium. By this newer method it was possible to obtain the metal in lumps about the size of marbles — no longer was it necessary to experiment with tiny aluminum particles of pinhead size. Deville's process marked a step further in aluminum production, introducing a method with commercial possibilities; however, it was still a far cry from the pig and ingot production of today.

charles martin hall

Even though the greatest minds of science had been and still were working on the problem, the secret of cheap aluminum was still uncovered when, on December 6, 1863, Charles Martin Hall was born to the wife of a minister in the small town of Thompson, Ohio, in the United States. By the time he was ready for high school, Hall's family moved to Oberlin, Ohio, where he later entered Oberlin College. Charles Hall was an ambitious student in science, spending much of his time experimenting in the home laboratories he had managed to set up. One day his science professor, Frank Fanning Jewett, ended his lecture session saying, "Whoever devises a process for the commercial production of aluminum will not only make a fortune for himself, but also will be a notable benefactor to the world!"

These words stuck in Hall's memory and seemed to present a challenge to him. He read everything that he could find pertaining to previous experiments with aluminum, diligently studying the methods and discoveries of Oersted, Wohler, and Deville. He graduated from college in 1885 and shortly afterwards began a full-time, persistent and ultimately successful search for a solution to the problem.

Failure after failure seemed only to increase his determination. When purely chemical methods failed to bring the solution any nearer, Hall turned to electrolysis. At first, these experiments were no more fruitful

Bright new pure pig aluminum as it comes from one of Reynolds Metals reduction plants

than the others. His particular problem was to find a suitable solvent for aluminum oxide, or alumina as it is called. At length, he discovered that cryolite, a sodium-aluminum-fluoride mineral, in the molten condition would dissolve alumina in large proportions. He proceeded to melt some cryolite in a clay crucible and dissolved alumina in it.

Then he passed an electric current through the solution for about two hours, but, when the molten mass was poured out, there was no aluminum. It occurred to him that perhaps impurities, principally silica from the clay crucible, had interfered with the process. Accordingly, he repeated the experiment; this time using a carbon crucible. Upon pouring out the material, he found small globules of aluminum. This was it! As crude and undeveloped as the process was at the time, it was destined to revolutionize the aluminum industry. During the five years that followed Hall's discovery on February 23, 1886, the price of aluminum dropped from between six and eight dollars a pound to sixty-five cents a pound. ✓

paul louis toussaint heroult

About the same time that Hall made his discovery, a young Frenchman named Paul Louis Toussaint Heroult also discovered the electrolytic method to cheap aluminum. Heroult was also born in 1863, on April 10, and in many instances his life paralleled that of Hall. Heroult had his laboratory in a small tannery in Gentilly and it was there that he made his discovery in *aluminium* as it is called in most foreign countries. Heroult received patent priorities in France, and priority was given to Hall in America. Of the countries foreign to both, some recognized Heroult and others gave Hall patent protection.

The discoveries of a process whereby commercial aluminum could be produced economically did not result in an overnight expansion of the industry. On the contrary, despite the obvious value of the process, there were many obstacles that prevented its immediate application for quantity production. Like most inventors, Hall himself had not the capital with which to realize the value of his process in operations. Moreover, while he knew how to attack and overcome the scientific problems which he met in the development of his process, the cautious, skeptical attitude of capitalists and businessmen whom he sought to adopt his method was an almost insurmountable problem to him. Nevertheless, such a truly revolutionary discovery was not to be suppressed by reluctant capital, and eventually this electro-

lytic method for economical production of aluminum was put into general use. The aluminum industry as we know it today was founded not by accident and with no reasonable amount of facility, but through the steady perseverance of Charles Martin Hall and Paul Louis Heroult who laid the cornerstone for an industry which has put aluminum among the five leading metals today, reduced the price to approximately 14 cents per pound, and inaugurated the light metal age.

2 • characteristics

Stacking highly finished Reynolds aluminum sheet as it comes from the stenciling machine

alloys: Like other metals, aluminum has only limited usefulness when in the pure state. It possesses many desirable characteristics — light weight, pleasing appearance, malleability, formability, excellent resistance to corrosive attack by industrial and marine atmospheres as well as by many chemicals and food products, high electrical and thermal conductivity, non-magnetic and non-sparking, superb reflectivity for light of all wave lengths and radiant heat, colorless and non-toxic compounds — but it lacks strength and hardness. This unusual combination of properties makes the pure metal useful in the form of foil, pigment, coatings, and electrical conductors; equipment and containers for chemicals, food products, beverages, and pharmaceuticals; and other articles where strength and hardness are of secondary importance. But if it were not possible to strengthen and harden the metal, it could not be used as a structural material. Fortunately, there are three methods for improving these properties — (1) addition of other metals to form alloys; (2) heat treatment of some types of alloys; (3) strain hardening by cold work.

The addition of alloying elements to aluminum not only increases the strength and hardness, but also changes other properties of the metal which for many applications are equally important to consider. The alterations to the inherent properties varies, depending on the nature and amount of alloying elements added. Thus, each alloy has been developed for a certain type of application with the various properties balanced to best fulfill the requirements of that application.

Some alloys were developed for cast products, others for wrought products. The casting alloys are used in producing sand castings, permanent mold castings, die castings, and centrifugal castings. The wrought alloys are used in producing sheet, plate, wire, rod, bar, shapes, tubing, pipe, forgings, and forging stock by rolling, extrusion, or forging.

Certain aluminum alloys with a wide range of properties are available in practically all forms in which metals are manufactured. However, all alloys are not made in all forms. Some alloys present manufacturing difficulties that make the cost prohibitive if manufactured in certain products. Other alloys have been developed primarily to overcome such manufacturing problems, and are fabricated only in the forms for which they were designed.

Special grabs and handling devices facilitate production and storage operations in Reynolds plants

Of the elements used in the production of commercial aluminum alloys, silicon, iron, copper, manganese, magnesium, chromium, nickel, and zinc are the most common. They may be used singly or in combination. Some of the high strength alloys are quite complex, containing as many as six intentionally added elements in addition to those present in controlled amounts as impurities.

Aluminum alloys are known commercially by a series of numbers or numbers and letters arbitrarily assigned by the producer. Alloy designations indicate definite chemical compositions, but, unlike designations for certain other materials, have no relation to each other.

tempers of wrought alloys: All wrought products are produced from cast ingots, the size and shape of which depend on the product and method of manufacture. The cast structure of the ingot is broken down by hot working: rolling, extrusion, or forging may be employed.

Some products are reduced to final dimensions without cooling, other than that which normally occurs during the fabricating process. Other products receive a final cold finishing operation, such as cold rolling or drawing through a die.

Cold working strain hardens the material, the increase in strength and hardness depending on the amount of reduction which it receives. By heating to the annealing temperature, the effects of cold working can be removed and the metal made soft and ductile.

Strain hardening is the only means of increasing the strength of some of the wrought aluminum alloys — the non-heat treatable or common alloys. In some products — sheet, wire, and round tubing — the various tempers are produced by cold working definite amounts after annealing. In other products — those not cold finished, or those cold finished only for dimensional accuracy or finish — these alloys are normally supplied in the "as fabricated" temper. This temper varies, depending on the size of the section and the amount of strain hardening, but is reasonably uniform for different lots of the same material because of standardization of the manufacturing process.

Other wrought aluminum alloys are strengthened by heat treatment or by a combination of heat treatment and strain hardening. These are known as strong or heat treatable alloys. The complete heat treatment process consists of two parts: first, a high temperature solution heat treatment followed by a drastic quench in a cooling medium;

and second, a precipitation or aging treatment at room or slightly elevated temperatures.

Temper designations, as follows, are suffixed to the alloy designation to indicate these mechanical and thermal treatments.

1 • TEMPER DESIGNATIONS FOR WROUGHT ALLOYS

	Temper		Produced By:
Non-Heat Treatable Alloys	O	soft	annealing
	¼H	one-quarter hard	definite amount of strain hardening by cold finishing
	½H	one-half hard	
	¾H	three-quarter hard	
	H	full hard	
	F	as fabricated	indefinite amount of strain hardening
Heat Treatable Alloys	O	soft	annealing
	W		solution heat treatment
	T		aging W temper material
	RT		strain hardening T temper material
	T5		aging extruded material

Some heat treatable wrought alloys are not produced in the W temper because after solution heat treatment they rapidly age at room temperature to the T temper. Alloys which are produced in the W temper may be converted to the T temper by a slightly elevated temperature aging or precipitation treatment.

tempers of casting alloys: Aluminum casting alloys, like the wrought alloys, are of two types: heat treatable and non-heat treatable alloys. Non-heat treatable casting alloys depend solely on the effect of the added alloying elements for improvement of properties. The properties of heat treatable casting alloys are further improved by solution and aging treatments similar to those used for the heat treatable wrought alloys. Temper designations — the letter T followed by one or more numbers — are suffixed to the alloy designation to indicate the various thermal treatments given to the casting alloys.

fabrication: All the common forms of fabrication used for metals are applied to aluminum alloys. Aluminum is cut to shape by blanking and routing. It is pierced and perforated; formed by embossing and coining, stamping and forging, drawing and spinning as well as by stretch forming, roll forming and brake forming.

The joining of aluminum is done by a number of different methods including the use of rivets, screws, clips and other mechanical fasteners. It is brazed, soldered and joined by adhesives. It is welded by oxyacetylene or oxyhydrogen torch; by metallic or carbon arc; and by the spot, seam or flash-butt resistance methods.

Both wrought and cast aluminum alloys are readily machined — at higher speeds than are possible with most other metals.

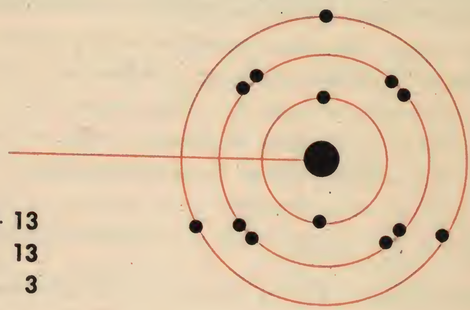
All the usual finishes — paint, enamel, lacquer, and plating — are applied to aluminum. Mechanical finishes such as sand blasted, hammered, scratch brushed and polished finishes are also used for decorative effects. Moreover, chemical and electrochemical finishes are used to increase resistance to wear and corrosion.

In most cases the same equipment that is used in fabricating other materials can be used for fabricating aluminum. However, there are certain differences in the characteristics of aluminum which must be taken into consideration if the best results are to be obtained.

atomic structure: The element aluminum, chemical symbol Al, has

the atomic number 13. According to present concepts, this means that an aluminum atom is composed of 13 electrons, each having a negative electrical charge of one, arranged in three orbits around a highly concentrated nucleus having a positive charge of 13. The three electrons in the outer orbit give the aluminum atom a valence or chemical combining power of 3.

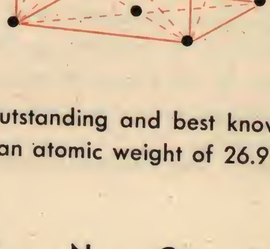
ALUMINUM ATOM



Nucleus
Electrical Charge = + 13
Atomic Number 13
Valence 3

crystal structure: When metals pass from the molten to the solid state, they assume crystalline structures. The atoms and molecules arrange themselves in definite, symmetrically ordered positions with respect to each other. Aluminum crystallizes with the face centered cubic arrangment of atoms, which is common to most of the ductile metals. The unit edge of the lattice cube for high purity aluminum has been determined as 4.04×10^{-8} cm.

ALUMINUM
CRYSTAL
STRUCTURE



Face Centered Cubic

density: Lightness is the outstanding and best known characteristic of aluminum. The metal has an atomic weight of 26.97 and a specific

gravity of 2.70, approximately one-third that of other commonly used metals. As with most metals, the density of aluminum decreases with increasing temperature.

Addition of other metals in the amounts commonly used in aluminum alloys does not appreciably change the density. The approximate weight of a cubic inch of aluminum and its alloys is one-tenth pound; equivalent to 170 pounds for a cubic foot.

Weight is an important factor to consider for all applications involving motion of mass. A saving in weight results in more pay load or greater economy of operation; less vibration and better performance of reciprocating and moving parts; less fatigue in the use of manually operated equipment; lower shipping, handling, and erection costs.

Although materials are purchased on a weight basis, they are usually used on a volume basis. When comparing the cost of aluminum with other materials, the price per pound should be divided by the ratio of specific gravities; approximately three for most common metals. In addition to the price per unit volume, the ease of fabricating and finishing the metal as well as its scrap value should be considered.

electrical conductivity: Aluminum has high electrical conductivity and consequently low resistivity, the reciprocal of conductivity. High purity aluminum has a volume conductivity of 64.6 percent of the International Annealed Copper Standard, but because of its low specific gravity the mass conductivity is 212.9 percent, greater than that for any other metal.

Addition of other metals lowers the electrical conductivity of aluminum: the amount of reduction depending on the amount and nature of the added elements. Thermal treatments have considerable effect on the conductivity of aluminum alloys, since elements in solid solution reduce the conductivity to a greater extent than undissolved constituents.

thermal conductivity: The high thermal conductivity of pure aluminum is reduced by the addition of alloying elements in the same manner as electrical conductivity.

thermal expansion: The coefficient of thermal expansion of aluminum is about twice that of ferrous metals and slightly greater than that of copper and its alloys. Most alloying elements when added to

aluminum have little effect on the coefficient, but relatively high percentages of silicon will reduce the value appreciably.

other thermal properties: Values for some thermal properties — such as boiling point, heat content, specific heat, heat of combustion, latent heat of fusion, and latent heat of vaporization — have been determined only for the pure metal. They may be applied to aluminum alloys, however, for calculations requiring only approximate values.

reflectivity: Aluminum has greater reflectivity for light and radiant heat than any other metal. The reflectivity increases with increase in wave length, reaching practically perfect reflectivity at very long wave lengths.

non-magnetic and non-sparking: Aluminum and its alloys are non-magnetic and non-sparking.

resistance to corrosion: The corrosion resistance of a material cannot be expressed quantitatively because it is only a relative term. No material is resistant to all conditions to which it might conceivably be exposed. It can only be compared with other materials under similar conditions.

Aluminum and aluminum alloys, however, are considered highly corrosion resistant and are widely used because of this desirable characteristic. Unlike other metals, aluminum has the ability to instantaneously form a thin, adherent film of hard oxide on freshly exposed surfaces, thus preventing further oxidation.

The addition of some alloying elements to aluminum reduces the corrosion resistance slightly. Magnesium, manganese, and chromium, however, have no adverse effect: silicon has but little. In general, the non-heat treatable alloys are more resistant to corrosion than the heat treatable alloys.

resistance to chemical attack: The protective hard oxide film on aluminum resists attack by a variety of chemicals. Many chemicals, including strong acids, have little or no effect on aluminum. Mild alkalies, especially if inhibited, are not injurious, but strong alkalies will dissolve the film and attack the aluminum. Sulfur compounds, harmful to most metals, do not affect aluminum.

Many chemicals, foods, beverages, and pharmaceuticals are produced, stored, or shipped in aluminum equipment: not only because of aluminum's resistance to chemical attack, but also because aluminum compounds are colorless and non-toxic. Staining, discoloration, and contamination are prevented.

modulus of elasticity: The modulus of elasticity of a material is the ratio of stress to corresponding strain in the elastic range. In tension and compression the average modulus for aluminum alloys is about 10,300,000 pounds per square inch, varying from 10,000,000 to 10,600,000 pounds per square inch for the various alloys.

Aluminum has a modulus which is approximately one-third that of steel — an asset when energy is to be absorbed. However, in order to maintain the same deflection characteristics when loaded as a beam, aluminum sections must be designed deeper than corresponding steel sections. Even so, at least a pound of weight can usually be saved for each pound of aluminum used, with an increase in strength obtained by proper selection of the alloy.

The modulus of rigidity, which is the modulus of elasticity in shear, is about 3,850,000 pounds per square inch for aluminum alloys, corresponding to a value of 0.33 for Poisson's Ratio.

mechanical properties: Typical mechanical properties of aluminum alloys shown in this booklet may be used in comparing the alloys with each other, or with other materials. It should be realized, however, that the values for different products may vary from these typical values: size, shape, method of manufacture, and type of test specimen all affect mechanical properties.

The guaranteed mechanical properties for an alloy, therefore, also will vary with size and product. Some of the variations are inherent in the material, but most are due to differences in size and type of test specimen required by standard testing practices.

high purity aluminum

SYMBOL	Al
ATOMIC NUMBER	13
ELECTRON ARRANGEMENT IN ATOM	(2) (8) 3
VALENCE	3
ATOMIC WEIGHT	26.97
ATOMIC VOLUME — cu cm/gram atom	10.0
ISOTOPES	none
CRYSTAL STRUCTURE	face-centered cubic
LATTICE EDGE — cm	4.04×10^{-8}

THERMAL

	°C	°F
MELTING POINT	658	1216
BOILING POINT	1800	3272

THERMAL CONDUCTIVITY AT 0–100°C (32–212°F)	
cal/cm/cm²/°C/sec	0.52
Btu/in/ft²/°F/hr	1,509
HEAT OF COMBUSTION	
cal/gram mol	380,000
Btu/lb mol	685,000
LATENT HEAT OF FUSION	
cal/gram	93
Btu/lb	167
LATENT HEAT OF VAPORIZATION — estimated	
cal/gram	2,000
Btu/lb	3,500

2 • COEFFICIENT OF THERMAL EXPANSION

TEMPERATURE RANGE		COEFFICIENT OF THERMAL EXPANSION	
°C	°F	per °C	per °F
20 – 100	68 – 212	.0000238	.0000132
20 – 200	68 – 392	.0000247	.0000137
20 – 300	68 – 572	.0000257	.0000143
20 – 400	68 – 752	.0000267	.0000148
20 – 500	68 – 932	.0000277	.0000154
20 – 600	68 – 1112	.0000287	.0000159
100 – 200	212 – 392	.0000255	.0000142
200 – 300	392 – 572	.0000275	.0000153
300 – 400	572 – 752	.0000295	.0000164
400 – 500	752 – 932	.0000315	.0000175
500 – 600	932 – 1112	.0000335	.0000186
300 – 600	572 – 1112	.0000315	.0000175

3 • SPECIFIC HEAT AND HEAT CONTENT

TEMPERATURE		HEAT CONTENT		SPECIFIC HEAT	
°C	°F	cal/kg	Btu/lb	mean 0° to T°	at T°
0	32	......	......	......	0.2220
100	212	22.59	40.66	0.2259	0.2297
200	392	45.94	82.69	0.2297	0.2374
300	572	70.07	126.12	0.2336	0.2451
400	752	94.97	170.95	0.2374	0.2529
500	932	120.64	217.15	0.2413	0.2606
600	1,112	147.90	264.76	0.2452	0.2683
657	1,214	162.50	292.50	0.2473	0.2727
657	1,214	256.46	461.63	0.3904	0.2502
700	1,292	267.27	481.09	0.3818	0.2523
800	1,472	292.74	526.93	0.3659	0.2517
900	1,652	318.70	573.66	0.3541	0.2619
1,000	1,832	345.14	621.26	0.3451	0.2667

high purity aluminum

4 • DENSITY VS. TEMPERATURE

TEMPERATURE		CONDITION	DENSITY		
°C	°F		g/cu cm	lb/cu in.	lb/cu ft
20	68	Solid	2.70	.0975	169
100	212	Solid	2.69	.0972	168
200	392	Solid	2.67	.0965	167
400	752	Solid	2.62	.0947	164
658	1216	Solid	2.55	.0921	159
658	1216	Liquid	2.38	.0860	149
700	1292	Liquid	2.37	.0856	148
800	1472	Liquid	2.34	.0845	146
900	1652	Liquid	2.32	.0838	145
1000	1832	Liquid	2.29	.0827	143
1100	2012	Liquid	2.26	.0816	141

CONTRACTION IN VOLUME FROM LIQUID AT MELTING POINT TO SOLID AT MELTING POINT — Percent 6.7

CONTRACTION IN VOLUME FROM LIQUID AT MELTING POINT TO SOLID AT 20°C (68°F) — Percent 11.9

CONTRACTION IN VOLUME FROM SOLID AT MELTING POINT TO SOLID AT 20°C (68°F) — Percent 5.6

ELECTRICAL

ELECTRICAL RESISTIVITY AT 0°C (32°F)

microhms/cu cm	2.44
ohms/mil-ft	14.7

ELECTRICAL RESISTIVITY AT 20°C (68°F)

microhms/cu cm	2.67
ohms/mil-ft	16.0

TEMPERATURE COEFFICIENT OF ELECTRICAL RESISTIVITY AT 20°C (68°F)	.0042
VOLUME ELECTRICAL CONDUCTIVITY AT 20°C (68° F) — Percent of Annealed Copper	64.6
MASS ELECTRICAL CONDUCTIVITY AT 20°C (68° F) — Percent of Annealed Copper	212.9
ELECTROCHEMICAL EQUIVALENT — grams/amp-hr	0.3354
ELECTRODE POTENTIAL AT 25°C (77°F) — volts	–1.69

MECHANICAL

MODULUS OF ELASTICITY

kg/mm^2	7,240
lb/sq in.	10.3×10^6

MODULUS OF RIGIDITY

kg/mm^2	2,710
lb/sq in.	3.85×10^6

POISSON'S RATIO	0.33

OTHER PROPERTIES

REFLECTIVITY FOR WHITE LIGHT — Percent	75—85
REFLECTIVITY FOR HEAT — Percent	85—95
MAGNETIC SUSCEPTIBILITY — cgs units	0.58×10^{-6}

nominal chemical compositions

ALLOY		SILICON	COPPER	MANGANESE	MAGNESIUM
5 : WROUGHT					
2S		....	....	....	....
3S		....	....	1.2	....
14S		0.8	4.4	0.8	0.4
17S		....	4.0	0.5	0.5
A17S		....	2.5	....	0.3
18S		....	4.0	....	0.5
24S		....	4.5	0.6	1.5
Pureclad 24S	Core	....	4.5	0.6	1.5
	Cladding	....	....	....	....
25S		0.8	4.5	0.8	....
32S		12.5	0.9	....	1.0
A51S		1.0	....	....	0.6
52S		....	....	....	2.5
56S		....	....	0.1	5.2
R301	Core	1.0	4.5	0.8	0.4
	Cladding	0.7	....	0.5	1.0
R303		....	1.3	....	2.5
R317		....	4.0	0.5	0.5
R353		0.7	....	....	1.3
R361		0.6	0.25	....	1.0

CHROMIUM	NICKEL	ZINC	LEAD	BISMUTH	ALUMINUM AND NORMAL IMPURITIES
ALLOYS					
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	2.0	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	0.9	....	....	....	Remainder
0.25	....	....	....	....	Remainder
0.25	....	....	....	....	Remainder
0.1	....	....	....	....	Remainder
....	....	....	....	....	Remainder
....	....	....	....	....	Remainder
0.25	0.1	6.5	....	....	Remainder
....	....	....	0.50	0.50	Remainder
0.25	....	....	....	....	Remainder
0.25	....	....	....	....	Remainder

nominal chemical compositions

ALLOY	SILICON	IRON	COPPER	MANGANESE
6 A • SAND-CASTING				
43	5.0	....	....	....
45	10.0	....	....	....
108	3.0	....	4.0	....
112	....	1.2	7.0	....
122	....	1.2	10.0	....
142	....	....	4.0	....
195	....	....	4.0	....
212	1.2	1.0	8.0	....
214	....	....	....	....
B214	1.8	....	....	....
220	....	....	....	....
A334	4.0	....	3.0	....
355	5.0	....	1.3	....
356	7.0	....	....	....
645	....	1.2	2.5	....
6 B • PERMANENT-MOLD				
43	5.0	....	....	....
A108	5.5	....	4.5	....
B113	1.7	1.2	7.0	....
C113	3.5	1.2	7.0	....
122	....	1.2	10.0	....
A132	12.0	....	0.8	....
138	4.0	1.0	10.0	....
142	....	....	4.0	....
B195	2.5	....	4.5	....
A214	....	....	....	....
B214	....	....	....	....
355	5.0	....	1.3	....
356	7.0	....	....	....

	MAGNESIUM	NICKEL	ZINC	ALUMINUM AND NORMAL IMPURITIES
ALLOYS				
	....	....	....	Remainder
	....	....	....	Remainder
	....	....	....	Remainder
	....	....	1.7	Remainder
	0.2	....	....	Remainder
	1.5	2.0	....	Remainder
	....	....	....	Remainder
	....	....	....	Remainder
	3.8	....	....	Remainder
	3.8	....	....	Remainder
	10.0	....	....	Remainder
	0.3	....	....	Remainder
	0.5	....	....	Remainder
	0.3	....	....	Remainder
	....	....	11.0	Remainder
CASTING ALLOYS				
	....	....	....	Remainder
	....	....	....	Remainder
	....	....	....	Remainder
	....	....	2.0	Remainder
	0.2	....	....	Remainder
	1.0	2.5	....	Remainder
	0.2	....	....	Remainder
	1.5	2.0	....	Remainder
	....	....	....	Remainder
	3.8	....	1.8	Remainder
	3.8	....	....	Remainder
	0.5	....	....	Remainder
	0.3	....	....	Remainder

nominal chemical composition

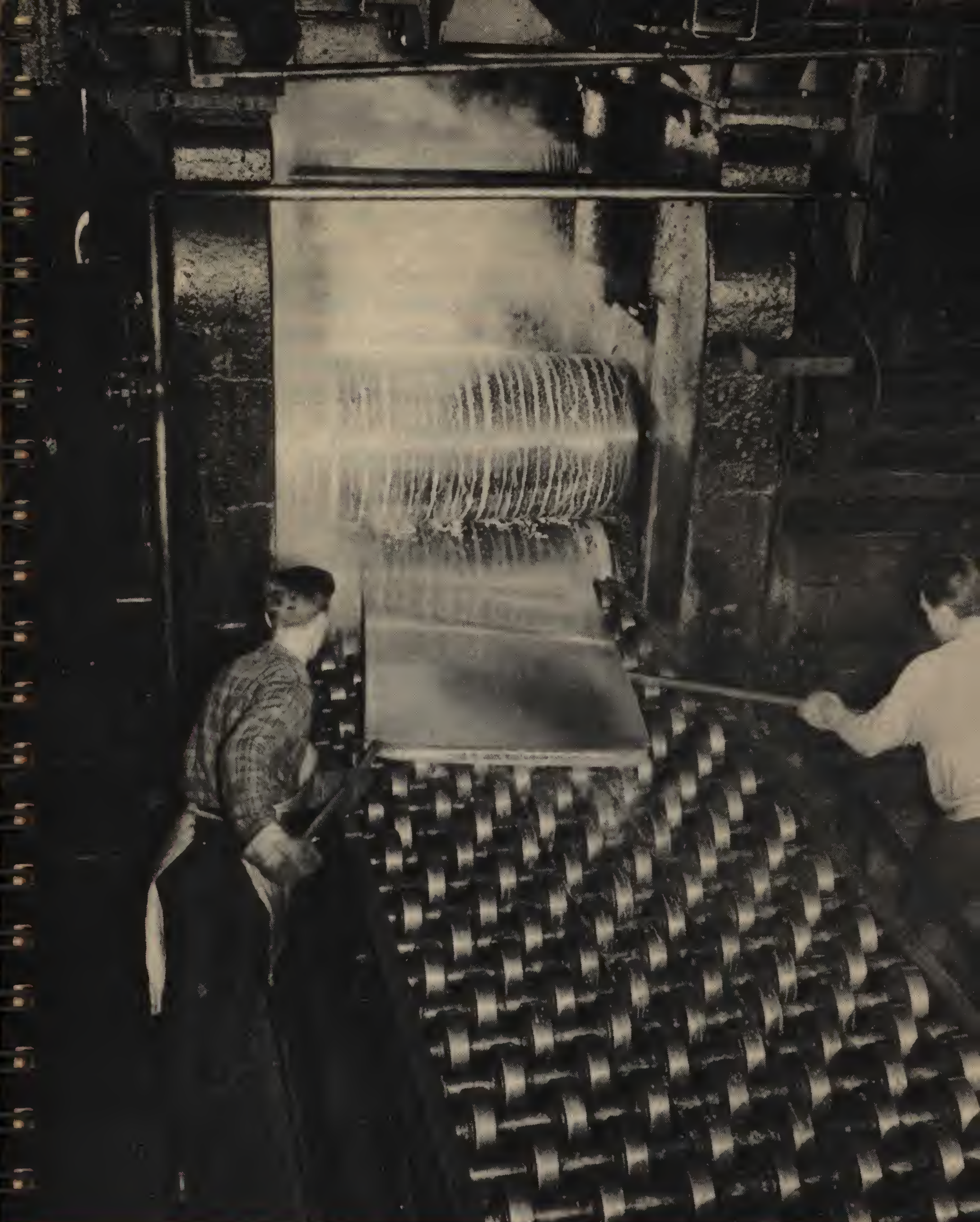
6C • DIE-CASTING ALLOYS				
ALLOY	COPPER	SILICON	MAGNESIUM	ALUMINUM PLUS NORMAL IMPURITIES
13	....	12.0	....	Remainder
43	....	5.0	....	Remainder
85	4.0	5.0	....	Remainder
218	....	....	8.0	Remainder
360	....	9.5	0.5	Remainder
380	3.5	8.5	....	Remainder

definitions

stress: The intensity (measured per unit area) of the internal distributed forces or components of force which resist a change in the form of a body. Stress is measured in force per unit area (pounds per square inch, kilograms per square millimeter, etc.). It is customary to calculate stress on the basis of the original dimensions of the cross-section of the body. There are three kinds of stress: tensile, compressive, and shearing. Flexure involves the combination of tensile stress and compressive stress. Torsion involves shearing stress.

strain: The change per unit of length in a linear dimension of a body, which change accompanies a stress. Strain is measured in inches per inch of length (or millimeters per millimeter, etc.). Under tensile stress or compressive stress, strain is measured along the dimension under consideration. Shearing strain is measured at right angles to the dimension under consideration. In torsion tests, which involve shearing stress, it is customary to measure the angle of twist, which may be translated into terms of strain.

yield strength: The stress in tension or compression at which a material exhibits a specified limiting permanent set. The specified



Hot rolling aluminum in Reynolds Plant No. 1 at Louisville

limiting set used for aluminum alloys is 0.002 inch per inch, or 0.2 percent. For aluminum alloys, the yield strength in tension is approximately equal to the yield strength in compression. It is usually impracticable and probably impossible to determine the stress at which inelastic action in a member begins. Plastic yielding in nearly all members (including the specimen in a carefully controlled laboratory test) starts as local actions and becomes measurable only after many local internal adjustments and accommodations have occurred, and after a considerable portion of the member is affected by the yielding.

ultimate strength or tensile strength: The maximum tensile stress which a material is capable of developing. In practice, it is considered to be the maximum stress developed by a specimen representing the material in a tension test carried to rupture, under definite prescribed conditions. Tensile strength is calculated from the maximum load carried during a tension test and the original cross-sectional area of the specimen.

elongation: The increase in distance between two gauge marks, placed on a tension test specimen before testing, as a result of stressing the specimen to fracture. The original distance between the gauge marks (gauge length) is 2 inches for the standard sheet specimen and 2 inches for the standard ½-inch diameter round specimen; when it is necessary to use a subsize round specimen the gauge length should always be equal to four times the diameter of the specimen. Since elongation over a fixed gauge length, such as 2 inches, varies with the form and size of test specimen, values obtained on standard sheet specimens of a given material vary with the thickness of the sheet from which they are cut; thin sheet, therefore, shows lower elongation values than thicker sheet.

modulus of elasticity: The ratio of stress to corresponding strain throughout the range of their proportionality. As there are three kinds of stress, so are there three moduli of elasticity for any material: the modulus in tension, the modulus in compression, and the modulus in shear. The modulus of elasticity is expressed in pounds per square inch (or kilograms per square millimeter, etc.).

The value of the modulus of elasticity in tension is nearly the same, for most metals, as the value of the modulus of elasticity in compression. For aluminum alloys, the modulus of elasticity varies somewhat with the alloy and is about 2 percent higher in compression than in tension: the average value is approximately 10,300,000 pounds per square inch.

The value of the modulus of elasticity in shear, also called modulus of rigidity, is smaller than the modulus of elasticity in tension. Aluminum alloys have a modulus of rigidity of approximately 3,850,000 pounds per square inch.

modulus of rigidity: Same as modulus of elasticity in shear.

poisson's ratio: The ratio of the strain in a direction normal to the direction of stressing to the strain in the direction of the stress, provided the stress is unidirectional and within the range of proportionality of stress to strain. Poisson's ratio (μ), modulus of elasticity (E), and modulus of rigidity (G) are interrelated as follows:

$$\mu = \frac{E}{2G} - 1$$

shearing strength: The maximum shearing stress which a material is capable of developing. In practice, it is considered to be the maximum average stress computed by dividing the ultimate load in the plane of shear by the area of the specimen subject to shear. Shearing strength is usually determined by inserting a cylindrical specimen through round holes in three hardened steel blocks, the center one of which is pulled (or pushed) between the other two so as to shear the specimen on two planes. The maximum load divided by the combined cross-sectional area of these two planes is the shearing strength.

endurance limit: The limiting stress below which a material will withstand without fracture on indefinitely large number of cycles of stress. In the case of aluminum alloys, endurance limits are based on 500,000,000 cycles of completely reversed stress, using the rotating beam type of machine and specimen.

brinell hardness: The hardness determined as the load applied to a ball divided by the spherical area of the impression made by impressing the ball into the surface of the material. In testing aluminum alloys a load of 500 kilograms is used on a ball 10 millimeters in diameter; when there is some reason for using a ball having a different diameter, the load (in kilograms) should be numerically equal to 5 times the square of the ball diameter (in millimeters). The following combinations of load and ball meet these requirements.

1000-kg. load on 14.3-mm. (9/16-in.) ball
500-kg. load on 10-mm. (0.3937-in.) ball
125-kg. load on 5-mm. (0.19690-in.) ball
12.6-kg. load on 1.59-mm. (1/16-in.) ball

typical mechanical properties

ALLOY AND TEMPER	TENSION			
	Strength psi		Elongation in 2 Inches percent	
	Ultimate	Yield	1/16 inch thick specimen	1/2 inch diameter specimen
7 • WROUGHT				
2S-O	13,000	5,000	35	45
2S-¼H	15,000	13,000	12	25
2S-½H	17,000	14,000	9	20
2S-¾H	20,000	17,000	6	17
2S-H	24,000	21,000	5	15
3S-O	16,000	6,000	30	40
3S-¼H	18,000	15,000	10	20
3S-½H	21,000	18,000	8	16
3S-¾H	25,000	21,000	5	14
3S-H	29,000	25,000	4	10
14S-O	27,000	14,000	....	18
14S-W	56,000	40,000	....	25
14S-T	70,000	60,000	....	13
17S-O	26,000	10,000	....	22
17S-T	62,000	40,000	....	22
A17S-T	43,000	24,000	....	27
18S-T	63,000	47,000	....	17
24S-O	27,000	11,000	19	22
24S-T	68,000	46,000	19	22
24S-RT	73,000	57,000	13	....
Pureclad 24S-T	64,000	43,000	18	....
Pureclad 24S-RT	67,000	53,000	11	....
25S-T	57,000	35,000	....	18
32S-T	56,000	46,000	....	8

COMPRESSION	SHEAR	FATIGUE	HARDNESS
Yield Strength psi	Shearing Strength psi	Endurance Limit psi	Brinell Number 500 kg load 10mm ball
ALLOYS			
5,000	9,500	5,000	23
13,000	10,000	6,000	28
14,000	11,000	7,000	32
17,000	12,000	8,500	38
21,000	13,000	8,500	44
6,000	11,000	7,000	28
15,000	12,000	8,000	35
18,000	14,000	9,000	40
21,000	15,000	9,500	47
25,000	16,000	10,000	55
14,000	18,000	11,000	45
40,000	34,000	18,000	100
60,000	42,000	18,000	135
10,000	18,000	11,000	45
40,000	38,000	18,000	105
24,000	28,000	13,500	70
47,000	......	14,500	115
11,000	18,000	12,000	42
45,000	41,000	18,000	120
55,000	42,000	......	130
43,000	40,000	......	......
53,000	41,000	......	......
35,000	35,000	15,000	110
46,000	38,000	14,000	125

typical mechanical properties

ALLOY AND TEMPER	TENSION			
	Strength psi		Elongation in 2 Inches percent	
	Ultimate	Yield	1/16 inch thick specimen	1/2 inch diameter specimen
8 • WROUGHT				
A51S-T	47,000	40,000	....	20
52S-O	29,000	14,000	25	30
52S-¼H	34,000	26,000	12	18
52S-½H	37,000	29,000	10	14
52S-¾H	39,000	34,000	8	10
52S-H	41,000	36,000	7	8
56S-O	42,000	20,000	....	35
56S-¼H	47,000	33,000	....	11
56S-½H	51,000	37,000	....	10
56S-¾H	55,000	43,000	....	9
56S-H	58,000	48,000	....	7
R301-O	25,000	10,000	....	22
R301-W	62,000	41,000	....	19
R301-T	68,000	60,000	....	10
R303-O	30,000	15,000	18	24
R303-T	77,000	71,000	9	14
R317-O	26,000	10,000	....	22
R317-T	62,000	40,000	....	22
R353-O	16,000	7,000	....	35
R353-W	33,000	20,000	....	30
R353-T	39,000	33,000	....	20
R361-O	18,000	8,000	22	....
R361-W	35,000	21,000	22	....
R361-T	45,000	39,000	12	....

COMPRESSION	SHEAR	FATIGUE	HARDNESS
Yield Strength psi	Shearing Strength psi	Endurance Limit psi	Brinell Number 500 kg load 10mm ball
A L L O Y S			
40,000	32,000	10,500	100
14,000	18,000	17,000	45
26,000	20,000	17,500	62
29,000	21,000	18,000	67
34,000	23,000	18,500	74
36,000	24,000	19,000	85
20,000	......	......	......
33,000	......	......	......
37,000	......	......	......
43,000	......	......	......
48,000	......	......	......
10,000	......	......	......
41,000	......	......	......
62,000	43,000	12,500	......
15,000	......	......	......
71,000	47,500	22,500	......
10,000	......	......	......
40,000	......	......	......
7,000	•11,000	8,000	26
20,000	20,000	13,000	65
33,000	24,000	13,000	80
8,000	12,500	9,000	30
21,000	24,000	13,500	65
39,000	30,000	13,500	95

typical mechanical properties

ALLOY AND TEMPER	TENSION			
	Strength psi		Elongation in 2 Inches percent	
	Ultimate	Yield	1/16 inch thick specimen	1/2 inch diameter specimen
9 • SAND-CASTING				
43	19,000	9,000	....	6.0
45	21,000	10,000	....	4.5
108	21,000	14,000	....	2.5
112	24,000	14,000	....	1.5
122	26,000	21,000	....	0.5
122-T2	27,000	20,000	....	0.5
142	28,000	24,000	....	1.0
142-T61	37,000	32,000	....	*
172	23,000	15,000	....	1.0
195-T4	32,000	16,000	....	8.5
195-T6	36,000	24,000	....	5.0
212	23,000	14,000	....	2.0
214	25,000	12,000	....	9.0
B214	20,000	13,000	....	2.0
220-T4	46,000	25,000	....	14.0
A334	25,000	18,000	....	2.0
355-T6	35,000	25,000	....	2.5
355-T7	38,000	35,000	....	1.0
355-T51	28,000	23,000	....	1.5
A355-T51	28,000	24,000	....	1.5
355-T71	35,000	29,000	....	1.5
356-T6	33,000	24,000	....	4.0
356-T41	25,000	20,000	....	2.0
406	19,000	9,000	....	12.0
645	29,000	17,000	....	4.0

* Less than 0.5%.

COMPRESSION	SHEAR	FATIGUE	HARDNESS
Yield Strength psi	Shearing Strength psi	Endurance Limit psi	Brinell Number 500 kg load 10mm ball
ALLOYS			
10,000	14,000	6,500	40
11,000	16,000	6,000	45
14,000	20,000	8,000	55
17,000	20,000	9,000	70
......	25,000	9,500	85
20,000	21,000	9,500	80
......	24,000	8,000	80
47,000	32,000	8,000	105
17,000	20,000	......	65
16,000	24,000	6,000	60
25,000	30,000	6,500	75
14,000	20,000	8,000	65
12,000	20,000	5,500	50
15,000	17,000	......	50
26,000	33,000	7,000	75
22,000	24,000	8,500	65
29,000	30,000	8,500	80
35,000	26,500	......	85
24,000	22,000	7,000	65
24,000	22,000	8,500	65
......	......	10,000	75
22,000	27,000	8,000	70
22,000	18,000	7,500	60
9,000	14,000	5,500	35
20,000	22,000	7,500	70

typical mechanical properties

ALLOY AND TEMPER	TENSION			
	Strength psi		Elongation in 2 Inches percent	
	Ultimate	Yield	1/16 inch thick specimen	1/2 inch diameter specimen
10A • PERMANENT-MOLD				
43	24,000	8,000	....	9.0
A108	28,000	16,000	....	2.0
B113	28,000	19,000	....	2.0
C113	30,000	28,000	....	1.0
122	31,000	26,000	....	1.0
A132-T551	36,000	28,000	....	0.5
142	34,000	24,000	....	1.0
142-T61	47,000	42,000	....	0.5
142-T571	40,000	34,000	....	1.0
B195-T4	40,000	22,000	....	10.0
B195-T6	45,000	33,000	....	5.0
A214	27,000	16,000	....	7.0
355-T6	43,000	27,000	....	4.0
355-T51	30,000	24,000	....	2.0
356-T6	40,000	27,000	....	5.0

10B • DIE				
13	37,000	18,000	....	1.8
A13	35,000	16,000	....	3.5
43	30,000	14,000	....	7.0
85	40,000	22,000	....	3.5
218	42,000	23,000	....	7.0
360	42,000	23,000	....	1.8
A360	40,000	20,000	....	4.5
380	45,000	25,000	....	2.0
A380	42,000	23,000	....	4.0

COMPRESSION	SHEAR	FATIGUE	HARDNESS
Yield Strength psi	Shearing Strength psi	Endurance Limit psi	Brinell Number 500 kg load 10mm ball
CASTING ALLOYS			
9,000	18,000	......	45
16,000	25,000	......	70
19,000	23,000	......	70
24,000	22,000	......	80
26,000	25,000	......	95
30,000	24,000	......	105
24,000	26,000	......	105
46,000	31,000	9,500	110
34,000	26,000	10,500	105
22,000	30,000	9,500	75
33,000	32,000	10,000	90
17,000	22,000	......	60
26,000	30,000	9,000	90
24,000	24,000	......	75
24,000	......	......	90

CASTING ALLOYS			
......	......	15,000	......
......	......	......	......
......	......	......	......
......	......	17,000	......
......	......	18,000	......
......	......	......	......
......	......	......	......
......	......	......	......
......	......	......	......

densities and expansions

ALLOY	SPECIFIC GRAVITY	DENSITY		
		lb/cu in.	lb/cu ft	g/cu cm
11A • WROUGHT				
2S	2.71	.098	169	2.71
3S	2.73	.099	171	2.73
14S	2.80	.101	175	2.80
17S	2.79	.101	175	2.79
A17S	2.74	.099	171	2.74
18S	2.80	.101	.175	2.80
24S	2.77	.100	173	2.77
25S	2.79	.101	175	2.79
32S	2.69	.097	168	2.69
A51S	2.69	.097	168	2.69
52S	2.67	.096	166	2.67
56S	2.64	.095	164	2.64
R301	2.80	.101	175	2.80
R303	2.82	.102	176	2.82
R317	2.81	.102	176	2.81
R353	2.69	.097	168	2.69
R361	2.70	.098	169	2.70
11B • SAND-CASTING				
43	2.66	.096	166	2.66
45	2.65	.096	166	2.66
108	2.75	.099	171	2.74
112	2.85	.103	178	2.85
122	2.85	.106	183	2.93
142	2.73	.099	171	2.74
142-T2	2.73	.099	171	2.74
142-T61	2.73	.099	171	2.74
142-T571	2.73	.099	171	2.74
195-T4	2.77	.100	173	2.77
195-T6	2.77	.100	173	2.77
195-T62	2.77	.100	173	2.77
212	2.83	.102	176	2.82
214	2.63	.095	164	2.63
B214	2.63	.095	164	2.63
220-T4	2.56	.092	159	2.55

AVERAGE COEFFICIENT OF THERMAL EXPANSION					
PER DEGREE CENTIGRADE			PER DEGREE FAHRENHEIT		
20-100°C	20-200°C	20-300°C	68-212°F	68-392°F	68-572°F
ALLOYS					
.0000239	.0000248	.0000259	.0000133	.0000138	.0000144
.0000239	.0000248	.0000259	.0000133	.0000138	.0000144
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000194	.0000205	.0000214	.0000108	.0000114	.0000119
.0000234	.0000245	.0000254	.0000130	.0000136	.0000141
.0000234	.0000245	.0000254	.0000130	.0000136	.0000141
.0000239	.0000248	.0000259	.0000133	.0000138	.0000144
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000232	.0000243	.0000259	.0000129	.0000135	.0000144
.0000220	.0000234	.0000248	.0000122	.0000130	.0000138
.0000234	.0000245	.0000254	.0000130	.0000136	.0000141
.0000234	.0000245	.0000254	.0000130	.0000136	.0000141
ALLOYS					
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000207	.0000214	.0000225	.0000115	.0000119	.0000125
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000234	.0000122	.0000127	.0000130
.0000225	.0000234	.0000245	.0000125	.0000130	.0000136
.0000225	.0000234	.0000245	.0000125	.0000130	.0000136
.0000225	.0000234	.0000245	.0000125	.0000130	.0000136
.0000225	.0000234	.0000245	.0000125	.0000130	.0000136
.0000229	.0000239	.0000248	.0000127	.0000133	.0000138
.0000229	.0000239	.0000248	.0000127	.0000133	.0000138
.0000229	.0000239	.0000248	.0000127	.0000133	.0000138
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000239	.0000248	.0000259	.0000133	.0000138	.0000144
.0000234	.0000245	.0000252	.0000130	.0000136	.0000140
.0000245	.0000254	.0000265	.0000136	.0000141	.0000147

densities and expansions

ALLOY	SPECIFIC GRAVITY	DENSITY		
		lb/cu in.	lb/cu ft	g/cu cm
12A • SAND-CASTING				
A334	2.73	.099	171	2.74
355-T6	2.68	.097	168	2.68
355-T51	2.68	.097	168	2.68
356-T6	2.63	.095	164	2.63
356-T51	2.63	.095	164	2.63
645	2.94	.106	183	2.93
12B • PERMANENT-MOLD				
43	2.68	.097	168	2.68
A108	2.77	.100	173	2.77
B113	2.86	.103	178	2.85
C113	2.86	.103	178	2.85
122	2.89	.104	180	2.87
A132-T551	2.68	.097	168	2.68
142	2.77	.100	173	2.77
142-T61	2.77	.100	173	2.77
142-T571	2.77	.100	173	2.77
B195-T4	2.78	.101	175	2.79
B195-T6	2.78	.101	175	2.79
A214	2.67	.096	166	2.66
355-T6	2.68	.097	168	2.68
355-T51	2.68	.097	168	2.68
356-T6	2.63	.095	164	2.63
12C • DIE				
13	2.66	.096	.....	.....
43	2.70	.097	.....	.....
81	2.85	.103	.....	.....
83	2.75	.099	.....	.....
85	2.78	.101	.....	.....
93	2.87	.104	.....	.....
218	2.53	.091	.....	.....
A254	2.66	.096	.....	.....
315	2.70	.097	.....	.....
505	2.80	.101	.....	.....

AVERAGE COEFFICIENT OF THERMAL EXPANSION					
PER DEGREE CENTIGRADE			PER DEGREE FAHRENHEIT		
20-100°C	20-200°C	20-300°C	68-212°F	68-392°F	68-572°F
ALLOYS					
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000214	.0000229	.0000234	.0000119	.0000127	.0000130
.0000214	.0000229	.0000234	.0000119	.0000127	.0000130
.0000234	.0000245	0000252	.0000130	.0000136	.0000140
CASTING ALLOYS					
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000214	.0000225	.0000228	.0000119	.0000125	.0000127
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000234	.0000122	.0000127	.0000130
.0000189	.0000200	.0000209	.0000105	.0000111	.0000116
.0000225	.0000234	.0000245	.0000125	.0000130	.0000136
.0000225	.0000234	.0000234	.0000125	.0000130	.0000130
.0000225	.0000234	.0000234	.0000125	.0000130	.0000130
.0000220	.0000229	.0000239	.0000122	.0000127	.0000133
.0000220	.0000229	.0000245	.0000122	.0000127	.0000136
.0000329	.0000248	.0000259	.0000133	.0000138	.0000144
.0000220	.0000229	.0000329	.0000122	.0000127	.0000133
.0000220	.0000229	.0000329	.0000122	.0000127	.0000133
.0000214	.0000229	.0000234	.0000119	.0000127	.0000130
CASTING ALLOYS					
....	....	....	.0000111	....	.0000119
....	....	....	.0000122	....	.0000133
....	....	....	.0000122	....	.0000133
....	....	....	.0000125	....	.0000138
....	....	....	.0000116	....	.0000127
....	....	....	.0000116	....	.0000127
....	....	....	.0000134	....	.0000145
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	.0000124	....	.0000134

thermal, electrical conductivity

ALLOY AND TEMPER	THERMAL CONDUCTIVITY AT 100°C (212°F)	
	cal/cm/cm²/°C/sec	Btu/in./ft²/°F/hr
13 • WROUGHT		
2S-O	.54	1550
2S-H	.52	1500
3S-O	.45	1300
3S-¼H	.39	1150
3S-½H	.38	1100
3S-H	.37	1050
14S-O	.45	1300
14S-T	.37	1050
17S-O	.41	1200
17S-T	.28	800
A17S-T	.37	1050
18S-O	.45	1300
18S-T	.37	1050
24S-O	.45	1300
24S-T	.28	800
25S-T	.37	1050
32S-O	.37	1050
32S-T	.32	950
A51S-O	.50	1450
A51S-W	.41	1200
A51S-T	.41	1200
52S-O	.37	1050
52S-H	.37	1050
56S-O	.28	800
56S-H	.26	750
R301-O	.45	1300
R301-W	.37	1050
R301-T	.37	1050
R303-T	.28	800
R317-O	.41	1200
R317-T	.28	800
R353-O	.41	1200
R353-W	.37	1050
R353-T	.37	1050
R361-O	.41	1200
R361-W	.37	1050
R361-T	.37	1050

ELECTRICAL CONDUCTIVITY AT 20°C (68°F) percent of annealed copper		ELECTRICAL RESISTIVITY AT 20°C (68°F)	
equal volume	equal weight	microhm/cu cm	ohm/mil-ft
ALLOYS			
59	195	2.9	18
57	185	3.0	18
50	160	3.4	21
42	135	4.1	25
41	135	4.2	25
40	130	4.3	26
50	160	3.4	21
40	130	4.3	26
45	145	3.8	23
30	95	5.7	35
40	130	4.3	26
50	160	3.4	21
40	130	4.3	26
50	160	3.4	21
30	95	5.7	35
40	130	4.3	26
40	130	4.3	26
35	115	4.9	30
55	185	3.1	19
45	150	3.8	23
45	150	3.8	23
40	135	4.3	26
40	135	4.3	26
29	100	5.9	36
27	90	6.4	38
50	160	3.4	21
40	130	4.3	26
40	130	4.3	26
30	95	5.7	35
45	145	3.8	23
30	95	5.7	35
45	150	3.8	23
40	130	3.4	26
40	130	3.4	26
45	150	3.8	23
40	130	3.4	26
40	130	3.4	26

thermal, electrical conductivity

ALLOY AND TEMPER	THERMAL CONDUCTIVITY AT 100°C (212°F)	
	cal/cm/cm²/°C/sec	Btu/in./ft²/°F/hr
14A • SAND-CASTING		
43	.34	1000
45	.29	850
108	.29	850
112	.28	800
122	.32	950
122-T2	.38	1100
122-T61	.31	900
142	.33	950
142-T2	.40	1150
142-T61	.35	1000
195-T4	.33	950
195-T62	.34	1000
212	.28	800
214	.32	950
B214	.35	1000
220-T4	.20	600
A334	.29	850
335-T6	.33	950
355-T51	.40	1150
A355-T51	.31	900
356-T4	.36	1050
356-T6	.36	1050
356-T51	.39	1150
645	.31	900
14B • PERMANENT-MOLD		
43	.38	1100
A108	.34	1000
B113	.28	800
C113	.26	750
122	.32	950
A132-T551	.28	800
142	.32	950
142-T571	.32	950
B195-T4	.33	950
B195-T6	.45	1300
355-T6	.36	1050
356-T6	.38	1100

ELECTRICAL CONDUCTIVITY AT 20°C (68°F) percent of annealed copper		ELECTRICAL RESISTIVITY AT 20°C (68°F)	
equal volume	equal weight	microhm/cu cm	ohm/mil-ft
ALLOYS			
37	125	4.7	28
31	105	5.6	33
31	100	5.6	33
30	95	5.8	35
34	105	5.1	31
41	130	4.2	25
33	105	5.2	31
36	120	4.8	29
44	145	3.9	24
37	120	4.7	28
35	115	4.9	30
37	120	4.7	28
30	95	5.8	35
35	120	4.9	30
38	130	4.5	27
21	75	8.2	49
31	100	5.6	33
36	120	4.8	29
43	145	4.0	24
32	105	5.4	32
39	130	4.4	27
39	130	4.4	27
43	145	4.0	24
33	100	5.2	31
CASTING ALLOYS			
41	135	4.2	25
37	120	4.7	28
29	90	6.0	36
27	85	6.4	38
34	105	5.1	31
29	95	6.0	36
34	110	5.1	31
34	110	5.1	31
35	110	4.9	30
50	160	3.5	21
39	130	4.4	27
41	140	4.2	25

thermal, electrical conductivity

14C • DIE		
ALLOY AND TEMPER	THERMAL CONDUCTIVITY AT 100°C (212°F)	
	cal/cm/cm²/°C/sec	Btu/in./ft²/°F/hr
13	.33	958
43	.38	1105
81	.27	784
83	.28	814
85	.27	784
93	.25	726
218	.24	697
A254	.18	523
315	.42	1218
505	.31	900

thermal treatments

15 • ANNEALING			
ALLOY	TO SOFTEN AFTER HEAT TREATMENT*		
	SOAKING TEMPERATURE °F	SOAKING TIME Hours	COOLING RATE **
2S		Not Heat Treated	
3S		Not Heat Treated	
14S	775 ± 25	2	B
17S	775 ± 25	2	B
24S	775 ± 25	2	B
Pureclad 24S	775 ± 25	2	B
52S		Not Heat Treated	
R301	775 ± 25	2	B
R303	685 ± 15	2	C
R317	775 ± 25	2	B
R353	775 ± 25	2	B
R361	775 ± 25	2	B

* Maximum drawability can not be obtained without mechanical working and subsequent re-annealing.

** Annealing cooling rates:
A — Air cool.
B — Furnace cool 50°F hr to 500°F.
C — Air cool to 450°F: soak 4 hrs. at 450° F.

CASTING ALLOYS

ELECTRICAL CONDUCTIVITY AT 20°C (68°F) percent of annealed copper		ELECTRICAL RESISTIVITY AT 20°C (68°F)	
equal volume	equal weight	microhm/cu cm	ohm/mil-ft
36	.....	4.79	28.8
41	.....	4.21	25.3
28	.....	6.16	37.0
30	.....	7.76	34.6
28	.....	6.16	37.0
26	.....	6.64	39.9
25	.....	6.90	41.5
18	.....	6.58	57.6
45	.....	3.84	23.1
33	.....	5.23	31.4

CYCLES

TO REMOVE COLD WORK		
SOAKING TEMPERATURE °F	SOAKING TIME Hours	COOLING RATE **
650 ± 15	½–2	A or B
750 ± 15	½–2	A or B
650 ± 10	½–2	A
650 ± 10	2	A
650 ± 10	2	A
650 ± 10	2	A
650 ± 10	2	A or B
650 ± 10	2	A
685 ± 15	2	C
650 ± 10	2	A
650 ± 10	2	A or B
650 ± 10	2	A or B

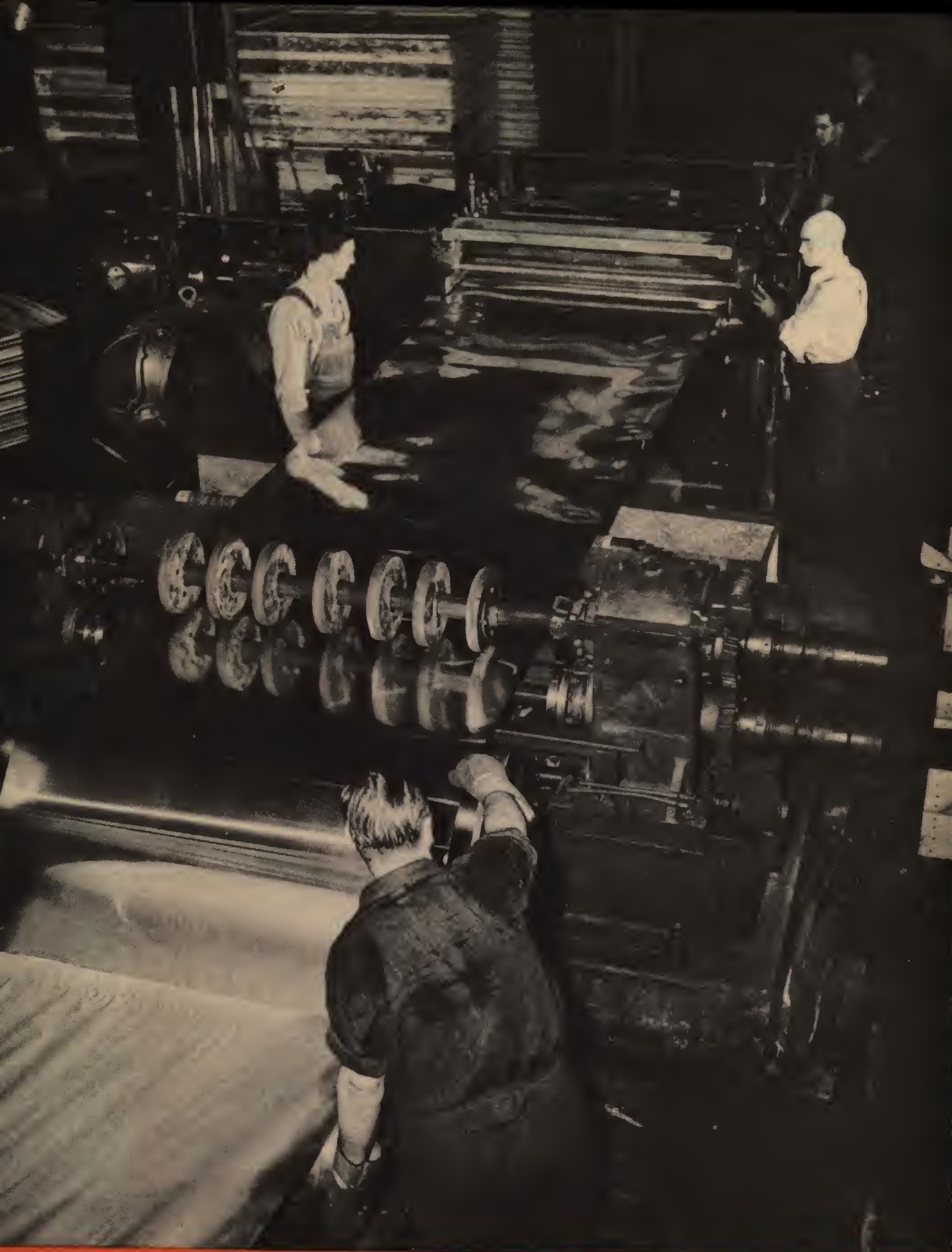
16 • HEAT TREATING

ALLOY	SOLUTION HEAT TREATMENT		
	SOAKING TEMPERATURE °F	QUENCH	TEMPER DESIGNATION φ
2S	Not Heat Treated		
3S	Not Heat Treated		
14S	930–945	Cold Water * *	W
17S	930–950	Cold Water	None
18S	950–970	Water or Oil	W
24S	910–930	Cold Water	None
Pureclad 24S	910–930	Cold Water	None
25S	955–975	Water or Oil	W
32S	950–970	Water or Oil	W
A51S	960–980	Water or Oil	W
52S	Not Heat Treated		
R301	930–950	Cold Water	W
R303 *	810–840	Cold Water * *	None
R317	930–950	Cold Water	None
R353	960–980	Cold Water	W
R361	960–980	Cold Water	W

φ When in the stable condition.
* Precipitation treatment should not be started until at least 24 hours after completion of solution heat treatment.
* *Hot water for extra heavy forgings.

CYCLES

PRECIPITATION TREATMENT (AGING)		
AGING TEMPERATURE °F	AGING TIME Hours	TEMPER DESIGNATION
Not Heat Treated		
Not Heat Treated		
360 ± 5 350 ± 5 340 ± 5 320 ± 5	5 8 10 18	T
Room	96–120	T
340 ± 5	10	T
Room	96–120	T
Room	96–120	T
340 ± 5 290 ± 5	12 18	T
340 ± 5	12	T
350 ± 5 320 ± 5	8 18	T
Not Heat Treated		
350 ± 5 320 ± 5	8 18	T
315 ± 5 275 ± 5	8 25	T315 T275
Room	96–120	T
320 ± 5 350 ± 5	18 8	T
320 ± 5 350 ± 5	18 8	T



Cutting sheets from a coil in a Reynolds foil plant

chemical applications

In the chemical and associated industries, many uses are found for aluminum. A few of the materials handled or processed with some information on the application are included in the following list:

Acetanilide: Acetylating tanks.

Acetic acid: Condensers, vacuum cleaners, vacuum receivers, storage tanks, tank cars, shipping drums, piping, fittings, stills.

Acetic Anhydride: Storage tanks, shipping containers.

Alcohol: Storage tanks, culture of fermentation tanks are used in the manufacture of the higher alcohols.

Aluminum Sulfate (alum): Cooling trays.

Ammonia and Ammonium Hydroxide: Pipe and fittings.

Ammonium Bicarbonate: Subliming apparatus.

Ammonium Nitrate: Neutralizing tanks, crystallizers.

Beer: Yeast tubs, yeast culture tanks, settling tubs, fermenters, carbonating tanks, skimmers, storage and government tanks, filters, pipe fittings, insulation, barrels, brew kettles, coolers, etc.

Benzaldehyde: Shipping containers.

Benzoic Acid: Subliming apparatus.

Benzene: Distilling equipment.

Butyric Acid: Shipping containers.

Carbolic Acid: Shipping containers (for the solid).

Carbon Dioxide: Mixing and filling equipment.

Citric Acid: Fermenting tanks, solution tanks, piping.

Coal: Aluminum hopper cars for high-sulfur coals.

Dairy Products: A wide variety of aluminum equipment used for handling and processing.

Distilled Water: Storage tanks and piping systems.

Dyes and Pigments: Aluminum equipment is used in the preparation of certain dyes to avoid discoloration. (Aluminum compounds are colorless.)

Dynamite: Dryers, mixers, packing machine parts. (Aluminum is non-sparking.)

Edible Fats and Oils: Equipment for processing, purifying, deodorizing and transportation.

Essential Oils: Shipping containers.

chemical applications

Ethyl Alcohol: See alcohol.

Ethylene Glycol: Processing apparatus.

Fatty Acids: Solidifying trays, storage tanks, condensers. Aluminum equipment may be used in all operations subsequent to distillation.

Formaldehyde: Distillation equipment, drums, storage vessels.

Food Products: Aluminum is widely used for processing food products, such as gelatin, fruit juices, dairy products, beverages, preserves, jellies, edible oils and fats, soups, cereals, sugar, etc.

Fuels and Oils: Shipping and storage containers, truck tanks, tank cars, aircraft tanks, pipe lines.

Gasoline: See fuels.

Gelatin: See foods.

Gluconic Acid: Fermenting tanks, solution tanks, piping.

Glyceryl Phosphate: Containers.

Guncotton: Produced in equipment having aluminum fume ducts, ventilating ducts, washing tanks and centrifugal extractors.

Hydrocyanic Acid: Shipping containers.

Hydrogen Peroxide: Shipping containers, storage equipment.

Hydrogen Sulfide: Ventilating hoods and ducts.

Lacquers: Shipping containers.

Lactic Acid: Fermenting equipment.

Methyl Saliculate: Shipping containers.

Milk: See dairy products.

Naval Stores: Stills, condensers, filters, storage tanks, tubing, turpentine cups, kettles, shipping containers.

Nitric Acid (80% or above): Shipping containers, tanks, pipe lines.

Nitro-glycerin: Storage and shipping containers.

Nitrous Gases: Covers for nitrating tanks, fume hoods, ventilating ducts.

Oils: See Edible Fats and Oils or Fuels and Oils.

Oleic Acid: See Fatty Acids.

Oxalic Acid: Aluminum processing equipment has been reported.

Paper: Piping for pure water and for sulfur dioxide, Fourdrinier rolls.

Paraldehyde: Shipping containers.

Petroleum (Industry): Roofing, paint, foil, condensers, heat exchanges, storage tanks, truck tanks, etc.

Phenol: See carbolic acid.

Potassium Chlorate: Drying trays.

Propylene Glycol: Processing apparatus.

Prussic Acid: See Hydrocyanic Acid.

Rayon (Industry): Storage tanks for processing chemicals, separator blades, reels, reel frames, thread guides, tension rods, spin buckets, skein arms, spools, piping, ventilating and heating ducts, etc.

Refrigerants: Aluminum equipment is used for handling ammonia, sulfur dioxide, F-12 (Freon) and inhibited brines.

Rosin: See Naval Stores.

Rubber (Industry): Molds, innertube mandrels, conduit, pans for coagulating latex, vulcanizing pans, latex cups, shipping containers for latex; pans, trays and tanks used in manufacture of hard rubber.

Sewage: Numerous applications.

Silk: Soaking machines for removing gums and resins, bleaching equipment.

Soaps: Collapsible tubes.

Sodium Chloride: Aluminum equipment is used for handling inhibited brine in refrigerating systems.

Stearic Acid: See Fatty Acids.

Sulfur: Hopper cars, piping.

Sulfur Dioxide: Ventilating equipment for handling fumes.

Sugar: Refining equipment.

Textiles: See Rayon, Silk, Wool, Dyes and Pigments.

Tooth Pastes and Powders: Cans and collapsible tubes.

Trinitrotoluene (T.N.T.): Melting equipment.

Turpentine: See Naval Stores.

Ultramarine (Paint Pigment): Trays for drying.

Varnish: Kettles.

Water: Piping systems, tanks, etc.

Wine: Piping.

Wool: Bleaching equipment.

3 • sheet and plate

Cold mill and runout table at Reynolds Richmond, Va., foil plant

definitions: Aluminum sheet and plate are defined as follows:

SHEET is a solid section having a thickness .006 to .249 inch inclusive; having two parallel surfaces brought to final dimension by rolling; having two longitudinal edges brought to final width by a slitting or shearing; and having two transverse edges brought to final length by shearing; furnished in flat lengths or in coils.

Flat Sheet is furnished in flat lengths and is usually sheared to width. It can be slit to width, however, if closer width tolerances are desired.

Coiled Sheet is furnished in coils and is always slit to width.

PLATE is a solid section having a thickness .250 inch or greater; having two parallel surfaces brought to final dimension by rolling; and having two longitudinal and two transverse edges brought to final width and length by shearing or sawing; furnished in flat lengths.

alloys, tempers, and sizes: The range of commercial sizes of sheet produced by Reynolds and standard sizes of sheet and plate are as shown on pages 72-75.

identification: If requested, flat sheet and plate will be identified by marking the alloy, temper, thickness, and other information in rows of constantly recurring symbols from one edge to the opposite edge with a suitable marking fluid.

packing: Flat sheet and plate of standard sizes are packed in cases usually weighing not less than 500 pounds net or, when requested, on skids. The weight of the skids, generally between 5000 and 20,000 pounds, depends on the capacity of the purchaser's handling equipment.

Sheets are oiled or interleaved with paper, depending on the size, alloy, temper, and destination.

ordering data: All orders for aluminum sheet and plate should include the following:

Quantity (in pounds, feet, or number of pieces)
Alloy and Temper
Thickness (in decimal fractions of an inch)
Length and Width (width only for coiled sheet)

Orders for coiled sheet should indicate the preferred inside and outside diameters and the minimum and maximum weight of coils.

commercial sizes*

THICKNESS Inches	STANDARD WIDTH Inches	MAXIMUM ROLLING LIMITS		AVAILABLE TEMPERS
		WIDTH Inches	LENGTH Inches	
17 • FLAT SHEET				
2S and 3S				
.0060-.007	18	24	144	0, ½H, ¾H, H
.0075-.009	24	30	144	0, ½H, ¾H, H
.0095-.011	24	36	144	0, ½H, ¾H, H
.0120-.014	24	42	144	0, ½H, ¾H, H
.0150-.016	36	48	144	0, ½H, ¾H, H
.0170-.018	36	48	144	0, ¼H, ½H, ¾H, H
.0190-.029	36	48	240	0, ¼H, ½H, ¾H, H
.0300-.128	48	54	240	0, ¼H, ½H, ¾H, H
.1290-.162	48	54	240	0, ¼H, ½H, ¾H
.1630-.249	48	54	240	0, ¼H, ½H
52S				
.0100-.011	16	24	144	0, ½H, ¾H, H
.0120-.014	24	30	144	0, ½H, ¾H, H
.0150-.016	24	36	144	0, ½H, ¾H, H
.0170-.018	24	36	144	0, ¼H, ½H, ¾H, H
.0190-.029	36	42	144	0, ¼H, ½H, ¾H, H
.0300-.037	48	48	220	0, ¼H, ½H, ¾H, H
.0380-.128	48	54	220	0, ¼H, ½H, ¾H, H
.1290-.162	48	54	220	0, ¼H, ½H, ¾H
.1630-.249	48	54	220	0, ¼H, ½H
24S and Pureclad 24S				
.0100-.014	24	28	144	0, T
.0150-.018	36	36	144	0, T
.0190-.024	36	42	144	0, T
.0250-.029	48	48	144	0, T
.0300-.037	48	48	220	0, T
.0380-.249	48	54	220	0, T
R301, R353, and R361				
.0100-.014	24	28	144	0, W, T
.0150-.018	36	36	144	0, W, T
.0190-.029	36	42	144	0, W, T
.0300-.037	48	48	144	0, W, T
.0380-.249	48	54	220	0, W, T

Refer to pages 74 and 75 for Reynolds Standard Sizes.

Maximum diameter of circles is same as maximum width of sheared sheet.

Maximum length that can be stretcher-leveled is 220 inches.

52S sheet in ¾H and H tempers cannot be stretcher-leveled.

*** Subject to change without notice.**

18 • COILED SHEET

THICKNESS Inches	MAXIMUM WIDTH Inches	AVAILABLE TEMPERS
2S and 3S — Mill Finish *		
.0060-.007	18	0, ¾H, H
.0075-.009	24	0, ¾H, H
.0095-.011	24	0, ½H, ¾H, H
.0120-.016	36	0, ½H, ¾H, H
.0170-.018	36	0, ¼H, ½H, ¾H, H
.0190-.053	48	0, ¼H, ½H, ¾H, H
.0540-.085	48	0, ¼H, ½H, H
.0860-.102	48	0, ¼H, H
2S and 3S — One Side Bright Mill Finish †		
.0060-.007	18	0, ¾H, H
.0075-.009	24	0, ¾H, H
.0095-.011	24	0, ½H, ¾H, H
.0120-.016	36	0, ½H, ¾H, H
.0170-.018	36	0, ¼H, ½H, ¾H, H
.0190-.053	48	0, ¼H, ½H, ¾H, H
.0540-.085	48	0, ¼H, ½H, H
2S and 3S — Standard One Side Bright Finish ‡		
.0060-.008	18	0, H
.0085-.011	24	0, H
.0120-.021	36	0, H
.0220-.067	48	0, H
52S — Mill Finish *		
.007	12	0, ¾H, H
.0075-.009	16	0, ¾H, H
.0095-.011	16	0, ½H, ¾H, H
.0120-.016	24	0, ½H, ¾H, H
.0170-.023	36	0, ¼H, ½H, ¾H, H
.0240-.053	48	0, ¼H, ½H, ¾H, H
.0540-.085	48	0, ¼H, ½H, H
.0860-.102	48	0, ¼H, H
52S — One Side Bright Mill Finish †		
.007	12	0, H
.0075-.011	16	0, H
.0120-.016	24	0, H
.0170-.023	36	0, H
.0240-.085	48	0, H

Maximum diameter of circles is 24 inches.

* MILL FINISH is an uncontrolled finish varying between bright and dull. Unless otherwise specified, sheet will be furnished with a Mill Finish.

† ONE SIDE BRIGHT MILL FINISH sheet has a polished appearance with a high degree of surface luster on one side of the sheet. This brightness may vary from sheet to sheet, or within a sheet, but one side will be distinctly brighter than the other.

‡ STANDARD ONE SIDE BRIGHT FINISH is much brighter than One Side Bright Mill Finish, one side of the sheet having a high degree of luster and depth of brightness that is uniform from sheet to sheet and within a sheet.

standard sizes*

19 • FLAT SHEET					
Thickness Inch	2S-O	2S-1/2H	3S-O	3S-1/2H	52S-O
.012	24 x 72	24 x 72	......	......	......
.016	24 x 72	24 x 72	24 x 72	24 x 72	......
.020	24 x 72	24 x 72	24 x 72	24 x 72	36 x 96
.025	24 x 72	24 x 72 36 x 96	24 x 72	24 x 72	36 x 96 ......
.032	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.040	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.051	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.064	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.072	......	......	......	......	......
.081	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.091	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.102	24 x 96 36 x 72	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.125	24 x 72 36 x 96	24 x 72 36 x 96 48 x 144	24 x 72 36 x 96	36 x 96 48 x 144	48 x 144 ....
.156	....	....	....	....	48 x 144 ......
.188	....	24 x 72 36 x 96 48 x 144	....	36 x 96 48 x 144	48 x 144 ....
.250	....	....	....	36 x 96 φ 48 x 144 φ	....

φ Indicates F (As-Rolled) Temper.
*** Subject to change without notice.**

AND PLATE

	52S-1/4H	52S-1/2H	R353 and R361 O. W, and T Tempers	24S 0 and T Tempers	Pureclad 24S 0 and T Tempers	R301 0, W, and T Tempers
	......	......	......	......	......	......
	......	......	......	......	......	......
	36 x 96	36 x 96	......	36 x 144	36 x 144	36 x 144
	36 x 96	36 x 96	36 x 144	36 x 144	48 x 144	48 x 144 ......
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	......	......	48 x 144	48 x 144	48 x 144	48 x 144
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ......
	36 x 96 48 x 144	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ....
	....	48 x 144	48 x 144	48 x 144	48 x 144	48 x 144 ......

composition

20 • SPECIFIED CHEMICAL

ALLOY		SILICON Min	SILICON Max	IRON Max	COPPER Min	COPPER Max	MANGANESE Min	MANGANESE Max
2S		..	..	1.0 *	..	.20	..	.10
3S		..	.60	.70	..	.20	1.0	1.5
17S		..	.80	1.0	3.5	4.5	.40	1.0
24S		..	.50	.50	3.8	4.9	.30	.90
Pure-clad 24S	Core	..	.50	.50	3.8	4.9	.30	.90
	Cladding	..	..	*.70	..	.10	..	.05
52S		..	..	*.45	..	.10	..	.10
R301	Core	.50	1.2	1.0	3.9	5.0	.40	1.2
	Cladding	..	..	*.70	..	.10	..	.05
R353		45%-65% of Magnesium		.35	..	.10	..	.10
R361		.40	.80	.70	.15	.40	..	.15

* Silicon plus iron.

COMPOSITION

MAGNESIUM		CHROMIUM		ZINC	TITANIUM	OTHERS		ALUMINUM
						EACH	TOTAL	
Min	Max	Min	Max	Max	Max	Max	Max	
..	..	..	..	.10	..	.05	.15	99.0 min.
..	..	..	..	.10	..	.05	.15	Remainder
.20	.80	..	.25	.10	..	.05	.15	Remainder
1.2	1.8	..	.25	.10	..	.05	.15	Remainder
1.2	1.8	..	.25	.10	..	.05	.15	Remainder
..	..	..	..	.10	..	..	..	99.3 min.
2.2	2.8	.15	.35	.10	..	.05	.15	Remainder
.20	.80	..	.25	.25	..	.05	.15	Remainder
..	..	..	..	.10	..	..	..	99.3
1.1	1.4	.15	.35	.25	..	.05	.15	Remainder
.80	1.2	..	.35	.10	.15	.05	.15	Remainder

specified mechanical properties

21 • NON-HEAT TREATABLE

ALLOY AND TEMPER	TENSILE STRENGTH Lb/Sq In. Minimum
2S	
2S-O	15,500 *
2S-¼H	14,000
2S-½H	16,000
2S-¾H	19,000
2S-H	22,000
3S	
3S-O	19,000 *
3S-¼H	17,000
3S-½H	19,500
3S-¾H	24,000
3S-H	27,000
52S	
52S-O	31,000 *
52S-¼H	31,000
52S-½H	34,000
52S-¾H	37,000
52S-H	39,000

* Non-heat treatable alloy plate is produced in only the F (as-fabricated or hot-rolled) temper, for which mechanical properties are not specified. Mechanical test specimens are taken parallel to direction of rolling from flat and coiled non-heat treatable alloy sheet in the ¼H and ½H tempers.

(COMMON) ALLOYS

ELONGATION IN 2 INCHES—Percent Minimum							
.006"–.007"	.008"–.012"	.013"–.019"	.020"–.031"	.032"–.050"	.051"–.113"	.114"–.161"	.162"–.249"
2S							
15	15	15	20	25	30	30	30
....	....	3	4	6	8	9	9
....	1	2	3	4	5	6	6
1	1	1	2	3	4	4	....
1	1	1	2	3	4	4	....
3S							
16	18	20	20	23	25	25	25
....	....	3	4	5	6	7	8
....	1	2	3	4	5	6	7
1	1	1	2	3	4	4	....
1	1	1	2	3	4	4	....
52S							
....	15	15	18	20	20	20	20
....	....	4	5	5	7	9	9
....	3	3	4	4	6	7	7
....	3	3	3	4	4	4	....
....	3	3	3	4	4	4	....

specified mechanical properties

22 • HEAT TREATABLE

ALLOY AND TEMPER	THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		ULTIMATE	YIELD	
17S				
17S-O	.010– .032	*35,000	....	12
	.033– .064	*35,000	....	12
	.065– .128	*35,000	....	12
	.129– .249	*35,000	....	12
	.250– .500	*35,000	....	12
17S-T	.010– .020	58,000	★34,000	15
	.021– .040	58,000	★34,000	†17
	.041– .128	58,000	★34,000	18
	.129– .249	58,000	★34,000	15
	.250– .500	58,000	★34,000	12
	.501–1.000	58,000	★34,000	10
	1.001–1.500	58,000	★34,000	9
	1.501–2.000	55,000	★34,000	8
	2.001–3.000	55,000	★34,000	6
17S	* Maximum ★ 33,000 for coiled sheet and sheet heat treated by the purchaser. † 18% minimum elongation for sheet less than 30″ wide.			
24S				
24S-O	.010– .032	*35,000	....	12
	.033– .063	*35,000	....	12
	.064– .128	*35,000	....	12
	.129– .249	*35,000	....	12
	.250– .500	*35,000	....	12
24S-T Flat	.010– .020	†64,000	★42,000	10
	.021– .040	†64,000	★42,000	13
	.041– .051	†64,000	★42,000	13
	.052– .128	†64,000	★42,000	15
	.129– .249	†64,000	★42,000	14
	.250– .500	62,000	40,000	12
	.501–1.000	62,000	40,000	8
	1.001–1.500	60,000	40,000	7
	1.501–2.000	60,000	40,000	6
24S	* Maximum † 62,000 for sheet heat treated by the purchaser. ★ 40,000 for sheet heat treated by the purchaser.			

(STRONG) ALLOYS

ALLOY AND TEMPER	THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		ULTIMATE	YIELD	
24S				
24S-T Coiled	.010– .020	62,000	40,000	12
	.021– .040	62,000	40,000	15
	.041– .051	62,000	40,000	15
	.052– .064	62,000	40,000	17
24S-RT	.020– .031	69,000	52,000	10
	.032– .036	69,000	52,000	11
	.037– .064	69,000	52,000	12
	.065– .128	69,000	52,000	12
	.129– .188	69,000	52,000	12
	.189– .249	69,000	52,000	10
	.250– .500	69,000	52,000	10
PURECLAD 24S				
Pureclad 24S-O	.010– .032	*33,000	....	8
	.033– .063	*33,000	....	10
	.064– .500	*34,000	....	12
Pureclad 24S-T Flat	.010– .020	★59,000	†39,000	10
	.021– .040	★59,000	†39,000	12
	.041– .063	★59,000	†39,000	13
	.064– .128	◐62,000	‡40,000	13
	.129– .249	◐62,000	‡40,000	11
	.250– .500	◐62,000	‡40,000	11
Pureclad 24S-T Coiled	.010– .020	56,000	37,000	11
	.021– .040	56,000	37,000	14
	.041– .063	56,000	37,000	15
	.064	60,000	38,000	13

Pureclad 24S

* Maximum
★ 56,000 for sheet heat treated by the purchaser.
† 37,000 for sheet heat treated by the purchaser.
◐ 60,000 for sheet and plate heat treated by the purchaser.
‡ 38,000 for sheet and plate heat treated by the purchaser.

specified mechanical properties

23 • HEAT TREATABLE

ALLOY AND TEMPER	THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		ULTIMATE	YIELD	
PURECLAD 24S				
Pureclad 24S-RT	.020– .031	62,000	48,000	8
	.032– .040	62,000	48,000	9
	.041– .063	62,000	48,000	10
	.064– .128	66,000	50,000	10
	.129– .188	66,000	50,000	10
	.189– .249	66,000	50,000	9
	.250– .500	66,000	50,000	9
R301				
R301-O	Up to .124	*30,000	....	16
	.125– .249	*30,000	....	16
	.250– .500	*30,000	....	16
★R301-W	Up to .039	56,000	37,000	14
	.040– .124	57,000	37,000	15
	.125– .249	57,000	37,000	15
	.250– .500	57,000	37,000	15
★R301-T	Up to .039	63,000	56,000	7
	.030– .050	64,000	57,000	8
	.051– .124	64,000	57,000	8
	.125– .249	64,000	57,000	8
	.250– .500	64,000	57,000	8

R301 * Maximum

★R301 sheet and plate heat treated by the purchaser shall conform to mechanical properties shown at right.

TEMPER	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
	YIELD	ULTIMATE	
W	55,000	34,000	15
T	62,000	54,000	8

(STRONG) ALLOYS

ALLOY AND TEMPER	THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		ULTIMATE	YIELD	
R353				
R353-O	.010– .032	*19,000	....	20
	.033– .064	*19,000	....	22
	.065– .128	*19,000	....	22
	.129– .258	*19,000	....	25
	.259– .500	*19,000	....	25
R353-W	.010– .032	28,000	16,000	12
	.033– .050	28,000	16,000	15
	.051– .258	28,000	16,000	20
	.259– .500	28,000	16,000	18
R353-T	.010– .031	35,000	28,000	8
	.032– .036	35,000	28,000	10
	.037– .064	35,000	28,000	10
	.065– .258	35,000	28,000	10
	.259– .500	35,000	28,000	10
R353 * Maximum.				
R361				
R361-O	.010– .020	*22,000	....	14
	.021– .128	*22,000	....	16
	.129– .249	*22,000	....	18
	.250– .500	*22,000	....	18
R361-W	.010– .020	30,000	16,000	14
	.021– .249	30,000	16,000	16
	.250– .500	30,000	16,000	18
R361-T	.010– .020	42,000	35,000	8
	.021– .036	42,000	35,000	10
	.037– .064	42,000	35,000	10
	.065– .128	42,000	35,000	10
	.129– .249	42,000	35,000	10
	.250– .500	42,000	35,000	10
R361 * Maximum.				

bend radii

24 • APPROXIMATE RADII						
ALLOY AND TEMPER	APPROXIMATE THICKNESS (T)—Inches					
	.016	.032	.064	.125	.188	.250
2S						
2S-O	0	0	0	0	0	0
2S-¼H	0	0	0	0	0-1T	0-1T
2S-½H	0	0	0	0	0-1T	0-1T
2S-¾H	0	0	0-1T	½T-1½T	1T-2T	1½T-3T
2S-H	0-1T	½T-1½T	1T-2T	1½T-3T	2T-4T	2T-4T
3S						
3S-O	0	0	0	0	0	0
3S-¼H	0	0	0	0	0-1T	0-1T
3S-½H	0	0	0	0-1T	0-1T	½T-1½T
3S-¾H	0-1T	0-1T	½T-1½T	1T-2T	1½T-3T	2T-4T
3S-H	½T-1½T	1T-2T	1½T-3T	2T-4T	3T-5T	4T-6T
17S						
17S-O	0	0	0	0	0-1T	0-1T
17S-T *	1T-2T	1½T-3T	2T-4T	3T-5T	4T-6T	4T-6T
24S						
24S-O †	0	0	0	0	0-1T	0-1T
24S-T † *	1½T-3T	2T-4T	3T-5T	4T-6T	4T-6T	5T-7T
24S-RT †	2T-4T	3T-5T	3T-5T	4T-6T	5T-7T	6T-10T

* immediately after quenching, these alloys can be formed over appreciably smaller radii.

† Pureclad 24S can be bent over slightly smaller radii than the corresponding tempers of the unclad material.

The above bend radii data are intended only as a guide in the selection of the minimum radius for a given material, or the hardest alloy and temper for a given radius. The minimum permissible radius varies with the nature of the forming operation, the type of forming equipment, and the design and condition of tools, and can only be determined accurately by actual trial under contemplated conditions of fabrication.

FOR 90° COLD BENDS

ALLOY AND TEMPER	APPROXIMATE THICKNESS (T)—Inches					
	.016	.032	.064	.125	.188	.250
52S						
52S-O	0	0	0	0	0	0
52S-¼H	0	0	0	0-1T	0-1T	½T-1½T
52S-½H	0	0	0-1T	½T-1½T	1T-2T	1½T-3T
52S-¾H	0-1T	½T-1½T	1T-2T	1½T-3T	2T-4T	2T-4T
52S-H	½T-1½T	1T-2T	1½T-3T	2T-4T	3T-5T	4T-6T
R301						
R301-O	0	0	0	0	0-1T	0-1T
R301-W	1T-2T	1½T-3T	2T-4T	3T-5T	4T-6T	4T-6T
R301-T	2T-4T	3T-5T	3T-5T	4T-6T	5T-7T	6T-8T
R353						
R353-O	0	0	0	0	0	0
R353-W	0-1T	½T-1½T	1T-2T	1½T-3T	2T-4T	2T-4T
R353-T	½T-1½T	1T-2T	1½T-3T	2T-4T	3T-5T	4T-6T
R361						
R361-O	0	0	0	0	0-1T	0-1T
R361-W	0-1T	0-1T	½T-1½T	1T-2T	1½T-3T	2T-4T
R361-T	0-1T	½T-1½T	1T-2T	1½T-3T	2T-4T	2T-4T

The above bend radii data are intended only as a guide in the selection of the minimum radius for a given material, or the hardest alloy and temper for a given radius. The minimum permissible radius varies with the nature of the forming operation, the type of forming equipment, and the design and condition of tools, and can only be determined accurately by actual trial under contemplated conditions of fabrication.

commercial tolerances

25 • STRONG ALLOYS						
WIDTH Inches	Over	..	18	36	48	54
	Thru	18	36	48	54	60
THICKNESS Inches		THICKNESS TOLERANCES—				
0.007-0.010		.001	.0015	....	....	....
0.011-0.017		.0015	.0015	....	....	....
0.018-0.028		.0015	.002	.0025	....	....
0.029-0.036		.002	.002	.0025	....	....
0.037-0.045		.002	.0025	.003	.004	.005
0.046-0.068		.0025	.003	.004	.005	.006
0.069-0.076		.003	.003	.004	.005	.006
0.077-0.096		.0035	.0035	.004	.005	.006
0.097-0.108		.004	.004	.005	.005	.007
0.109-0.140		.0045	.0045	.005	.005	.007
0.141-0.172		.006	.006	.008	.008	.009
0.173-0.203		.007	.007	.010	.010	.011
0.204-0.249		.009	.009	.011	.011	.013
0.250-0.320		.013	.013	.013	.013	.015
0.321-0.438		.019	.019	.019	.019	.020
0.439-0.625		.025	.025	.025	.025	.025
0.626-0.875		.030	.030	.030	.030	.030
0.876-1.125		.035	.035	.035	.035	.035
1.126-1.375		.040	.040	.040	.040	.040
1.376-1.625		.045	.045	.045	.045	.045
1.626-1.875		.052	.052	.052	.052	.052
1.876-2.250		.060	.060	.060	.060	.060
2.251-2.750		.075	.075	.075	.075	.075
2.751-3.000		.090	.090	.090	.090	.090

Tolerances apply only to commercial sizes.

—FLAT AND COILED

60	66	72	78	84	90	96
66	72	78	84	90	96	120
Inches Plus or Minus						
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
....	....	....	....	....	....	....
.006	.007	.008	.009	....	....	....
.008	.010	.010	.011	.012	....	....
.008	.010	.010	.011	.012	....	....
.010	.012	.013	.014	.016	.018	.020
.010	.012	.013	..014	.016	.018	0.20
.012	.014	.015	.016	.017	.019	.023
.014	.016	.017	.017	.017	.022	.026
.016	.018	.018	.018	.018	.024	.028
.018	.020	.020	.020	.020	.025	.030
.020	.023	.023	.025	.025	.026	.033
.025	.025	.030	.030	.030	.035	.035
.030	.030	.037	.037	.037	.045	.045
.035	.035	.045	.045	.045	.055	.055
.040	.040	.052	.052	.052	.065	.065
.045	.045	.060	.060	.060	.075	.075
.052	.052	.070	.070	.070	.088	.088
.060	.060	.080	.080	.080	.100	.100
.075	.075	.100	.100	.100	....	....
.090	.090	.120	.120	....	....	....

tolerances

26 • COMMERCIAL

THICKNESS Inches	WIDTH SLITTING TOLERANCE—Inches Widths Thru 3″		
	Widths Thru 3″	Widths Over 3″ Thru 24″	Widths Over 24″
.006- .102	±1/64	±1/32	±3/64
.103- .249	....	....	....
.250- .500	....	....	....
.501-1.000	....	....	....

THICKNESS Inches	LENGTH SHEAR TOLERANCE—Inches		
	Lengths Thru 18″	Lengths Over 18″ Thru 48″	Lengths Over 48″ Thru 120″
.006- .249	±1/16	±3/32	±1/8
.250- ,500	+3/8	+3/8	+3/8
.501-1.000	+1/2	+1/2	+1/2

TOLERANCES

WIDTH

FLAT SHEAR TOLERANCE—Inches

Widths Thru 4″	Widths Over 4″ Thru 18″	Widths Over 18″ Thru 36″	Widths Over 36″ Thru 54″	Widths Over 54″ Thru 72″	Widths Over 72″ Thru 102″
±1/32	±1/16	±3/32	±1/8	±5/32	±3/16
....	±3/32	±1/8	±3/16	±3/16	±1/4
....	+3/8	+3/8	+3/8	+3/8	+3/8
....	+1/2	+1/2	+1/2	+1/2	+1/2

LENGTH

SHEAR TOLERANCE—Inches

Lengths Over 120″ Thru 144″	Lengths Over 144″ Thru 180″	Lengths Over 180″ Thru 240″	Lengths Over 240″ Thru 540″
±5/32	±5/32	±1/4	±1/4
+3/8	+7/16	+7/16	+1/2
+1/2	+9/16	+9/16	+5/8

commercial tolerances

WIDTH Inches Over		18	36	54	72	90	102
WIDTH Inches Thru	18	36	54	72	90	102	132
THICKNESS Inches	THICKNESS TOLERANCES—Inches Plus or Minus						
0.006-0.007	.001	.001	..	..	..	..	..
0.008-0.010	.001	.0015	..	..	..	..	..
0.011-0.017	.0015	.0015	.002	..	..	..	..
0.018-0.028	.0015	.002	.0025	..	..	..	..
0.029-0.036	.002	.002	.0025	.0035	..	..	..
0.037-0.045	.002	.0025	.003	.004	..	..	..
0.046-0.068	.0025	.003	.004	.005	.007	..	..
0.069-0.076	.0025	.003	.004	.006	.008	..	..
0.077-0.096	.003	.003	.004	.006	.008	..	..
0.097-0.108	.0035	.004	.005	.007	.009	.010	..
0.109-0.140	.0045	.0045	.005	.007	.009	.010	..
0.141-0.172	.006	.006	.008	.009	.011	.012	..
0.173-0.203	.007	.007	.009	.011	.013	.015	..
0.204-0.249	.009	.009	.011	.013	.015	.017	..
0.250-0.320	.013	.013	.013	.015	.017	.020	..
0.321-0.438	.019	.019	.019	.019	.023	.026	.026
0.439-0.625	.025	.025	.025	.025	.030	.035	.035
0.626-0.875	.030	.030	.030	.030	.037	.045	.045
0.876-1.125	.035	.035	.035	.035	.045	.055	.055
1.126-1.375	.040	.040	.040	.040	.052	.065	.065
1.376-1.625	.045	.045	.045	.045	.060	.075	.075
1.626-1.875	.052	.052	.052	.052	.070	.088	.088
1.876-2.250	.060	.060	.060	.060	.080	.100	.100
2.251-2.750	.075	.075	.075	.075	.100	.125	.125
2.751-3.000	.090	.090	.090	.090	.120	.150	..

Table title: 27 • COMMON ALLOYS, FLAT AND COILED

Tolerances apply only to commercial sizes.

28 • MAXIMUM FOR LATERAL BOW, CAMBER

WIDTH Inches	FLAT SHEET		COILED SHEET
	Lengths Thru 12′	Lengths Over 12′	
Thru 4	1½″ in 10′	1½″ in 10′	1½″ in 10′
Over 4	⅛″ in 10′	1½″ in 10′	1½″ in 10′

Lateral bow is measured as the distance from the point of maximum bow to a straight line along the concave edge of the sheet.

weights:

The weight tables in this booklet are based on the density of 2S, which is 0.0979 pounds per cubic inch. If more accurate determination of weight for other aluminum alloys is desired, the applicable conversion factor should be used. Conversion factors for other metals and alloys are also shown for ready reference.

$$\text{weight of} \left\{ \begin{array}{r@{\,=\,}l} \text{3S} & 1.01 \\ \text{17S} & 1.03 \\ \text{24S} & 1.02 \\ \text{52S} & .98 \\ \text{R353} & .993 \\ \text{R361} & .996 \\ \text{brass} & 3.1 \\ \text{copper} & 3.3 \\ \text{nickel} & 3.26 \\ \text{steel} & 2.89 \\ \text{zinc} & 2.6 \end{array} \right\} \times \text{weight of 2S}$$

30 • WEIGHTS OF CIRCLES

DIAMETER Inches	THICKNESS .010	.012	.016	.020	.025	.032	.040	.051	.064
2	.00308	.00369	.00493	.00616	.00770	.00985	.0123	.0157	.0197
2¼	.00390	.00468	.00623	.00779	.00974	.0124	.0156	.0199	.0249
2½	.00481	.00577	.00770	.00962	.0120	.0154	.0192	.0245	.0308
2¾	.00582	.00698	.00931	.0116	.0146	.0186	.0233	.0297	.0373
3	.00693	.00831	.0111	.0139	.0173	.0222	.0277	.0353	.0443
3¼	.00813	.00976	.0130	.0163	.0203	.0260	.0325	.0415	.0520
3½	.00943	.0113	.0151	.0189	.0236	.0302	.0377	.0481	.0603
3¾	.0108	.0130	.0173	.0216	.0270	.0346	.0433	.0552	.0693
4	.0123	.0148	.0197	.0246	.0308	.0394	.0493	.0628	.0788
4¼	.0139	.0167	.0222	.0278	.0348	.0445	.0556	.0709	.0889
4½	.0156	.0187	.0249	.0312	.0390	.0499	.0623	.0795	.0997
4¾	.0174	.0208	.0278	.0347	.0434	.0556	.0695	.0886	.111
5	.0192	.0231	.0308	.0385	.0481	.0616	.0770	.0981	.123
5¼	.0212	.0255	.0339	.0424	.0530	.0679	.0849	.108	.136
5½	.0233	.0279	.0373	.0466	.0582	.0745	.0931	.119	.149
5¾	.0254	.0305	.0407	.0509	.0636	.0814	.102	.130	.163
6	.0277	.0333	.0443	.0554	.0693	.0887	.111	.141	.177
6¼	.0301	.0361	.0481	.0601	.0752	.0962	.120	.153	.192
6½	.0325	.0390	.0520	.0650	.0813	.104	.130	.166	.208
6¾	.0351	.0421	.0561	.0701	.0877	.112	.140	.179	.224
7	.0377	.0453	.0603	.0754	.0943	.121	.151	.192	.241
7¼	.0405	.0485	.0647	.0809	.101	.129	.162	.206	.259
7½	.4033	.0520	.0693	.0866	.108	.139	.173	.221	.277
7¾	.0462	.0555	.0740	.0925	.116	.148	.185	.236	.296
8	.0493	.0591	.0788	.0985	.123	.158	.197	.251	.315
8¼	.0524	.0629	.0838	.105	.131	.168	.210	.267	.335
8½	.0556	.0667	.0890	.111	.139	.178	.222	.284	.356
8¾	.0589	.0707	.0943	.118	.147	.189	.236	.301	.377
9	.0623	.0748	.0998	.125	.156	.199	.249	.318	.399
9¼	.0659	.0790	.105	.132	.165	.211	.263	.336	.421
9½	.0695	.0834	.111	.139	.174	.222	.278	.354	.445
9¾	.0732	.0878	.117	.146	.183	.234	.293	.373	.468
10	.0770	.0924	.123	.154	.192	.246	.308	.393	.493
10¼	.0809	.0970	.129	.162	.202	.259	.323	.412	.518

— pounds per piece

— Inches

.072	.081	.091	.102	.125	.156	.188	.250	.312	.375
.0222	.0249	.0280	.0314	.0385	.0480	.0579	.0770	.0961	.115
.0281	.0316	.0355	.0397	.0487	.0608	.0733	.0974	.122	.146
.0346	.0390	.0438	.0491	.0601	.0750	.0904	.120	.150	.180
.0419	.0471	.0530	.0594	.0728	.0908	.109	.146	.182	.218
.0499	.0561	.0630	.0707	.0866	.108	.130	.173	.216	.260
.0585	.0659	.0740	.0829	.102	.127	.153	.203	.254	.305
.0679	.0764	.0858	.0962	.118	.147	.177	.236	.294	.354
.0779	.0877	.0985	.110	.135	.169	.203	.271	.338	.406
.0887	.0997	.112	.126	.154	.192	.232	.308	.384	.462
.100	.113	.127	.142	.174	.217	.261	.348	.434	.521
.112	.126	.142	.159	.195	.243	.293	.390	.486	.585
.125	.141	.158	.177	.217	.271	.327	.434	.542	.651
.139	.156	.175	.196	.241	.300	.362	.481	.600	.722
.153	.172	.193	.216	.265	.331	.399	.530	.662	.796
.168	.189	.212	.237	.291	.363	.438	.582	.726	.873
.183	.206	.232	.260	.318	.397	.478	.636	.794	.954
.200	.224	.252	.283	.346	.432	.521	.693	.865	1.04
.216	.244	.274	.307	.376	.469	.565	.752	.938	1.13
.234	.263	.296	.332	.406	.507	.611	.813	1.01	1.22
.252	.284	.319	.358	.438	.547	.659	.877	1.09	1.32
.272	.305	.343	.385	.471	.588	.709	.943	1.18	1.41
.291	.328	.368	.413	.506	.631	.761	1.01	1.26	1.52
.312	.351	.394	.442	.541	.675	.814	1.08	1.35	1.62
.333	.374	.421	.472	.578	.721	.869	1.16	1.44	1.73
.355	.399	.448	.502	.616	.768	.926	1.23	1.54	1.85
.377	.424	.477	.534	.655	.817	.985	1.31	1.63	1.96
.400	.450	.506	.567	.695	.868	1.05	1.39	1.74	2.09
.424	.477	.536	.601	.737	.919	1.11	1.47	1.84	2.21
.449	.505	.567	.636	.779	.973	1.17	1.56	1.95	2.34
.474	.533	.599	.672	.823	1.03	1.24	1.65	2.05	2.47
.500	.563	.632	.709	.868	1.08	1.31	1.74	2.17	2.60
.527	.593	.666	.746	.915	1.14	1.38	1.83	2.28	2.74
.554	.623	.700	.785	.962	1.20	1.45	1.92	2.40	2.89
.582	.655	.736	.825	1.01	1.26	1.52	2.02	2.52	3.03

weights

31 • WEIGHTS OF CIRCLES

DIAMETER	THICKNESS								
Inches	.010	.012	.016	.020	.025	.032	.040	.051	.064
10½	.0849	.102	.136	.170	.212	.272	.339	.433	.543
10¾	.0889	.107	.142	.178	.222	.285	.356	.454	.569
11	.0931	.112	.149	.186	.233	.298	.373	.475	.596
11¼	.0974	.117	.156	.195	.244	.312	.390	.497	.623
11½	.102	.122	.163	.204	.254	.326	.407	.519	.651
11¾	.106	.128	.170	.213	.266	.340	.425	.542	.680
12	.111	.133	.177	.222	.277	.355	.443	.565	.709
12¼	.116	.139	.185	.231	.289	.370	.462	.589	.739
12½	.120	.144	.192	.241	.301	.385	.481	.613	.770
12¾	.125	.150	.200	.250	.313	.400	.501	.638	.801
13	.130	.156	.208	.260	.325	.416	.520	.663	.832
13¼	.135	.162	.216	.270	.338	.432	.541	.689	.865
13½	.140	.168	.224	.281	.351	.449	.561	.715	.898
13¾	.146	.175	.233	.291	.364	.466	.582	.742	.931
14	.151	.181	.241	.302	.377	.483	.603	.769	.966
14¼	.156	.188	.250	.313	.391	.500	.625	.797	1.00
14½	.162	.194	.259	.324	.405	.518	.647	.825	1.04
14¾	.167	.201	.268	.335	.419	.536	.670	.354	1.07
15	.173	.208	.277	.346	.433	.554	.693	.883	1.11
15¼	.179	.215	.286	.358	.447	.573	.716	.913	1.15
15½	.185	.222	.296	.370	.462	.592	.740	.943	1.18
15¾	.191	.229	.305	.382	.477	.611	.764	.974	1.22
16	.197	.236	.315	.394	.493	.631	.788	1.00	1.26
16¼	.203	.244	.325	.406	.508	.650	.813	1.04	1.30
16½	.210	.251	.335	.419	.524	.671	.838	1.07	1.34
16¾	.216	.259	.346	.432	.540	.691	.864	1.10	1.38
17	.222	.267	.356	.445	.556	.712	.890	1.13	1.42
17¼	.229	.275	.366	.458	.573	.733	.916	1.17	1.47
17½	.236	.283	.377	.471	589	.754	.943	1.20	1.51
17¾	.243	.291	388	.485	.606	.776	.970	1.24	1.55
18	.249	.299	.399	.499	.623	.798	.998	1.27	1.60
18¼	.256	.308	.410	.513	.641	.820	1.03	1.31	1.64
18½	.263	.316	.421	.527	.659	.843	1.05	1.34	1.69
18¾	.271	.325	.433	.541	.676	.866	1.08	1.38	1.73

— pounds per piece (cont'd)

—Inches

.072	.081	.091	.102	.125	.156	.188	.250	.312	.375
.611	.687	.772	.866	1.06	1.32	1.60	2.12	2.65	3.18
.640	.720	.809	.907	1.11	1.39	1.67	2.22	2.78	3.34
.671	.754	.848	.950	1.16	1.45	1.75	2.33	2.91	3.49
.701	.789	.886	.994	1.22	1.52	1.83	2.44	3.04	3.65
.733	.825	.926	1.04	1.27	1.59	1.91	2.54	3.18	3.82
.765	.861	.967	1.08	1.33	1.66	2.00	2.66	3.32	3.98
.798	.898	1.01	1.13	1.39	1.73	2.08	2.77	3.46	4.16
.832	.936	1.05	1.18	1.44	1.80	2.17	2.89	3.60	4.33
.866	.974	1.09	1.23	1.50	1.88	2.26	3.01	3.75	4.51
.901	1.01	1.14	1.28	1.56	1.95	2.35	3.13	3.90	4.69
.937	1.05	1.18	1.33	1.62	2.03	2.45	3.25	4.06	4.88
.973	1.09	1.23	1.38	1.69	2.11	2.54	3.38	4.22	5.07
1.01	1.14	1.28	1.43	1.75	2.19	2.64	3.51	4.38	5.26
1.05	1.18	1.32	1.48	1.82	2.27	2.74	3.64	4.54	5.46
1.09	1.22	1.37	1.54	1.89	2.35	2.84	3.77	4.71	5.66
1.13	1.27	1.42	1.59	1.95	2.44	2.94	3.91	4.88	5.86
1.17	1.31	1.47	1.65	2.02	2.52	3.04	4.05	5.05	6.07
1.21	1.36	1.52	1.71	2.09	2.61	3.15	4.19	5.22	6.28
1.25	1.40	1.58	1.77	2.16	2.70	3.26	4.33	5.40	6.49
1.29	1.45	1.63	1.83	2.24	2.79	3.37	4.47	5.58	6.71
1.33	1.50	1.68	1.89	2.31	2.88	3.48	4.62	5.77	6.93
1.37	1.55	1.74	1.95	2.39	2.98	3.59	4.77	5.96	7.16
1.42	1.60	1.79	2.01	2.46	3.07	3.70	4.93	6.15	7.39
1.46	1.65	1.85	2.07	2.54	3.17	3.82	5.08	6.34	7.62
1.51	1.70	1.91	2.14	2.62	3.27	3.94	5.24	6.54	7.86
1.55	1.75	1.97	2.20	2.70	3.37	4.06	5.40	6.74	8.10
1.60	1.80	2.02	2.27	2.78	3.47	4.18	5.56	6.94	8.34
1.65	1.86	2.08	2.34	2.86	3.57	4.31	5.73	7.15	8.59
1.70	1.91	2.15	2.40	2.95	3.68	4.43	5.89	7.35	8.84
1.75	1.96	2.21	2.47	3.03	3.78	4.56	6.06	7.57	9.09
1.80	2.02	2.27	2.54	3.12	3.89	4.69	6.23	7.78	9.35
1.85	2.08	2.33	2.61	3.20	4.00	4.82	6.41	8.00	9.61
1.90	2.13	2.40	2.69	3.29	4.11	4.95	6.59	8.22	9.88
1.95	2.19	2.46	2.76	3.38	4.22	5.09	6.76	8.44	10.1

32 • WEIGHTS OF CIRCLES

DIA-METER Inches	THICKNESS								
	.010	.012	.016	.020	.025	.032	.040	.051	.064
19	.278	.333	.445	.556	.695	.889	1.11	1.42	1.78
19¼	.285	.342	.456	.570	.713	.913	1.14	1.45	1.83
19½	.293	.351	.468	.585	.732	.937	1.17	1.49	1.87
19¾	.300	.360	.480	.600	.751	.961	1.20	1.53	1.92
20	.308	.369	.493	.616	.770	.985	1.23	1.57	1.97
20¼	.316	.379	.505	.631	.789	1.01	1.26	1.61	2.02
20½	.323	.388	.518	.647	.809	1.04	1.29	1.65	2.07
20¾	.331	.398	.530	.663	.828	1.06	1.33	1.69	2.12
21	.339	.407	.543	.679	.849	1.09	1.36	1.73	2.17
21¼	.348	.417	.556	.695	.869	1.11	1.39	1.77	2.22
21½	.356	.427	.569	.712	.889	1.14	1.42	1.81	2.28
21¾	.364	.437	.583	.728	.910	1.17	1.46	1.86	2.33
22	.373	.447	.596	.745	.931	1.19	1.49	1.90	2.38
22¼	.381	.457	.610	.762	.953	1.22	1.52	1.94	2.44
22½	.390	.468	.623	.779	.974	1.25	1.56	1.99	2.49
22¾	.398	.478	.637	.797	.996	1.27	1.59	2.03	2.55
23	.407	.489	.651	.814	1.02	1.30	1.63	2.08	2.61
23¼	.416	.499	.666	.832	1.04	1.33	1.66	2.12	2.66
23½	.425	.510	.680	.850	1.06	1.36	1.70	2.17	2.72
23¾	.434	.521	.695	.868	1.09	1.39	1.74	2.21	2.78
24	.443	.532	.709	.887	1.11	1.42	1.77	2.26	2.84
24¼	.453	.543	.724	.905	1.13	1.45	1.81	2.31	2.90
24½	.462	.554	.739	.924	1.16	1.48	1.85	2.36	2.96
24¾	.471	.566	.754	.943	1.18	1.51	1.89	2.40	3.02
25	.481	.577	.770	.962	1.20	1.54	1.92	2.45	3.08
25¼	.491	.589	.785	.981	1.23	1.57	1.96	2.50	3.14
25½	.500	.601	.801	1.00	1.25	1.60	2.00	2.55	3.20
25¾	.510	.612	.817	1.02	1.28	1.63	2.04	2.60	3.27
26	.520	.624	.832	1.04	1.30	1.66	2.08	2.65	3.33
26¼	.530	.636	.849	1.06	1.33	1.70	2.12	2.70	3.39
26½	.541	.649	.865	1.08	1.35	1.73	2.16	2.76	3.46
26¾	.551	.661	.881	1.10	1.38	1.76	2.20	2.81	3.52
27	.561	.673	.898	1.12	1.40	1.80	2.24	2.86	3.59
27¼	.572	.686	.914	1.14	1.43	1.83	2.29	2.91	3.66

— pounds per piece (cont'd)

— Inches

.072	.081	.091	.102	.125	.156	.188	.250	.312	.375
2.00	2.25	2.53	2.83	3.47	4.33	5.22	6.95	8.67	10.4
2.05	2.31	2.60	2.91	3.57	4.45	5.36	7.13	8.90	10.7
2.11	2.37	2.66	2.99	3.66	4.57	5.50	7.32	9.13	11.0
2.16	2.43	2.73	3.06	3.75	4.68	5.64	7.51	9.37	11.3
2.22	2.49	2.80	3.14	3.85	4.80	5.79	7.70	9.61	11.5
2.27	2.56	2.87	3.22	3.95	4.92	5.93	7.89	9.85	11.8
2.33	2.62	2.94	3.30	4.04	5.05	6.08	8.09	10.1	12.1
2.39	2.68	3.02	3.38	4.14	5.17	6.23	8.28	10.3	12.4
2.44	2.75	3.09	3.46	4.24	5.29	6.38	8.49	10.6	12.7
2.50	2.82	3.16	3.55	4.34	5.42	6.53	8.69	10.8	13.0
2.56	2.88	3.24	3.63	4.45	5.55	6.69	8.89	11.1	13.3
2.62	2.95	3.31	3.71	4.55	5.68	6.85	9.10	11.4	13.7
2.68	3.02	3.39	3.80	4.66	5.81	7.00	9.31	11.6	14.0
2.74	3.09	3.47	3.89	4.76	5.94	7.16	9.53	11.9	14.3
2.81	3.16	3.55	3.97	4.87	6.08	7.33	9.74	12.2	14.6
2.87	3.23	3.63	4.06	4.98	6.21	7.49	9.96	12.4	14.9
2.93	3.30	3.71	4.15	5.09	6.35	7.65	10.2	12.7	15.3
3.00	3.37	3.79	4.24	5.20	6.49	7.82	10.4	13.0	15.6
3.06	3.44	3.87	4.34	5.31	6.63	7.99	10.6	13.3	16.0
3.13	3.52	3.95	4.43	5.43	6.77	8.16	10.9	13.5	16.3
3.19	3.59	4.03	4.52	5.54	6.92	8.33	11.1	13.8	16.6
3.26	3.67	4.12	4.62	5.66	7.06	8.51	11.3	14.1	17.0
3.33	3.74	4.20	4.71	5.78	7.21	8.69	11.6	14.4	17.3
3.39	3.82	4.29	4.81	5.89	7.36	8.86	11.8	14.7	17.7
3.46	3.90	4.38	4.91	6.01	7.50	9.04	12.0	15.0	18.0
3.53	3.97	4.47	5.01	6.13	7.66	9.23	12.3	15.3	18.4
3.60	4.05	4.55	5.11	6.26	7.81	9.41	12.5	15.6	18.8
3.67	4.13	4.64	5.21	6.38	7.96	9.59	12.8	15.9	19.1
3.75	4.21	4.73	5.31	6.50	8.12	9.78	13.0	16.2	19.5
3.82	4.30	4.83	5.41	6.63	8.27	9.97	13.3	16.5	19.9
3.89	4.38	4.92	5.51	6.76	8.43	10.2	13.5	16.9	20.3
3.97	4.46	5.01	5.62	6.88	8.59	10.4	13.8	17.2	20.6
4.04	4.54	5.11	5.72	7.01	8.75	10.5	14.0	17.5	21.0
4.12	4.63	5.20	5.83	7.14	8.92	10.7	14.3	17.8	21.4

33 • WEIGHTS OF CIRCLES

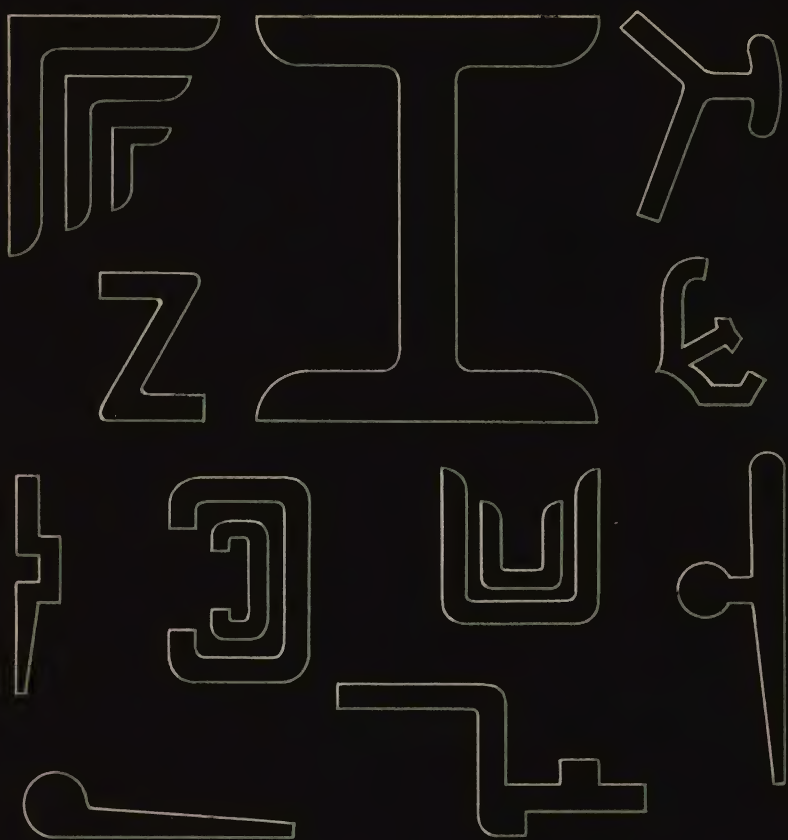
DIAMETER Inches	THICKNESS .010	.012	.016	.020	.025	.032	.040	.051	.064
27½	.582	.698	.931	1.16	1.46	1.86	2.33	2.97	3.73
27¾	.593	.711	.948	1.19	1.48	1.90	2.37	3.02	3.79
28	.603	.724	.965	1.21	1.51	1.93	2.41	3.08	3.86
28¼	.614	.737	.983	1.23	1.54	1.97	2.46	3.13	3.93
28½	.625	.750	1.00	1.25	1.56	2.00	2.50	3.19	4.00
28¾	.636	.763	1.02	1.27	1.59	2.04	2.54	3.24	4.07
29	.647	.777	1.04	1.29	1.62	2.07	2.59	3.30	4.14
29¼	.659	.790	1.05	1.32	1.65	2.11	2.63	3.36	4.21
29½	.670	.804	1.07	1.34	1.67	2.14	2.68	3.42	4.29
29¾	.681	.817	1.09	1.36	1.70	2.18	2.72	3.47	4.36
30	.693	.831	1.11	1.39	1.73	2.22	2.77	3.53	4.43
30¼	.704	.845	1.13	1.41	1.76	2.25	2.82	3.59	4.51
30½	.716	.859	1.15	1.43	1.79	2.29	2.86	3.65	4.58
30¾	.728	.873	1.16	1.46	1.82	2.33	2.91	3.71	4.66
31	.740	.888	1.18	1.48	1.85	2.37	2.96	3.77	4.73
31¼	.752	.902	1.20	1.50	1.88	2.41	3.01	3.83	4.81
31½	.764	.916	1.22	1.53	1.91	2.44	3.05	3.89	4.89
31¾	.776	.931	1.24	1.55	1.94	2.48	3.10	3.96	4.97
32	.788	.945	1.26	1.58	1.97	2.52	3.15	4.02	5.04
32¼	.801	.961	1.28	1.60	2.00	2.56	3.20	4.08	5.12
32½	.813	.976	1.30	1.63	2.03	2.60	3.25	4.15	5.20
32¾	.826	.991	1.32	1.65	2.06	2.64	3.30	4.21	5.28
33	.838	1.01	1.34	1.68	2.10	2.68	3.35	4.27	5.36
33¼	.851	1.02	1.36	1.70	2.13	2.72	3.40	4.34	5.45
33½	.864	1.04	1.38	1.73	2.16	2.76	3.46	4.41	5.53
33¾	.877	1.05	1.40	1.75	2.19	2.81	3.51	4.47	5.61
34	.890	1.07	1.42	1.78	2.22	2.85	3.56	4.54	5.69
34¼	.903	1.08	1.44	1.81	2.26	2.89	3.61	4.60	5.78
34½	.916	1.10	1.47	1.83	2.29	2.93	3.66	4.67	5.86
34¾	.929	1.12	1.49	1.86	2.32	2.97	3.72	4.74	5.95
35	.943	1.13	1.51	1.89	2.36	3.02	3.77	4.81	6.03
35¼	.956	1.15	1.53	1.91	2.39	3.06	3.83	4.88	6.12
35½	.970	1.16	1.55	1.94	2.43	3.10	3.88	4.95	6.21
35¾	.984	1.18	1.57	1.97	2.46	3.15	3.93	5.02	6.30
36	.998	1.20	1.60	1.99	2.49	3.19	3.99	5.09	6.38

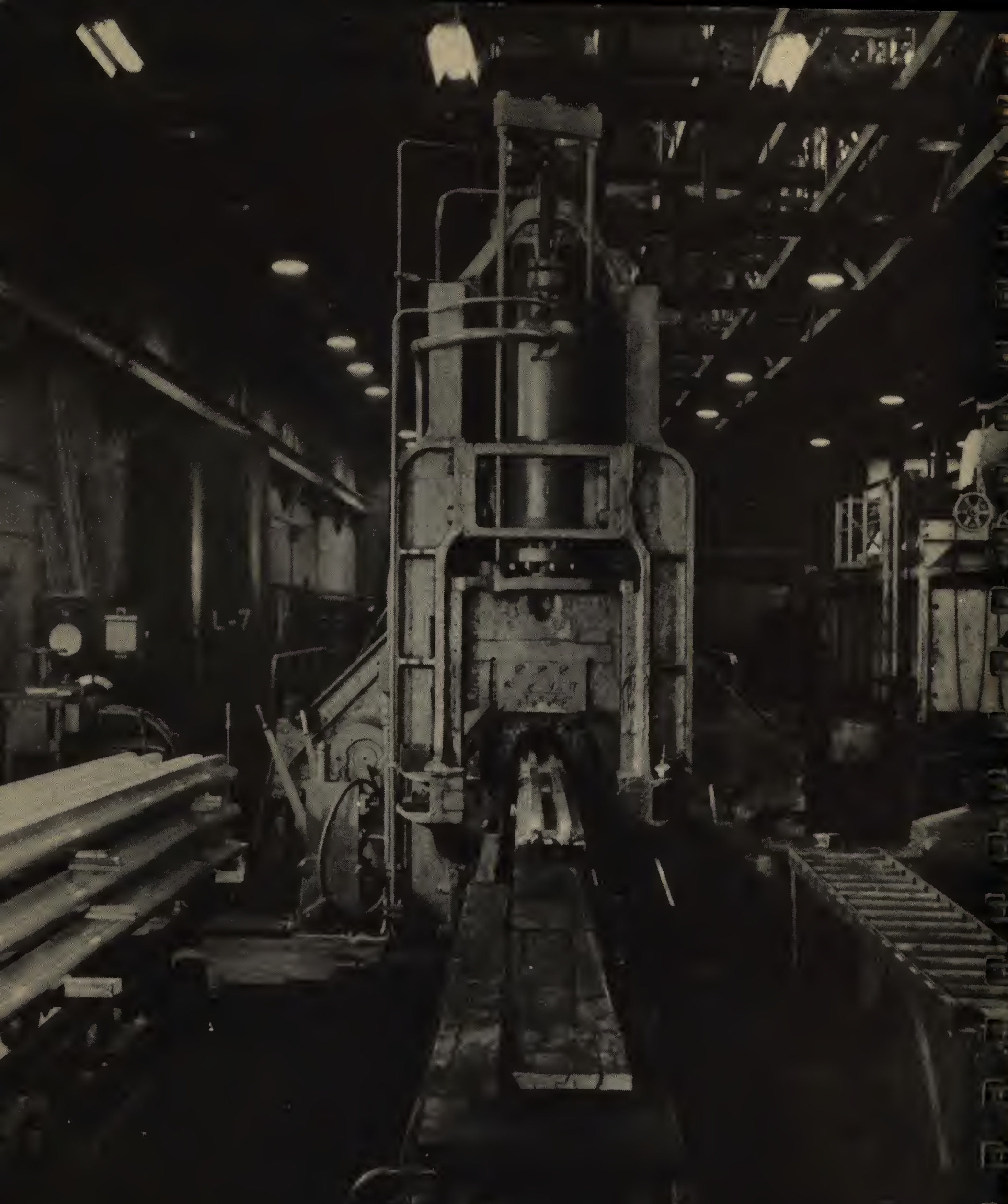
— pounds per piece (concluded)

— Inches

.072	.081	.091	.102	.125	.156	.188	.250	.312	.375
4.19	4.71	5.30	5.94	7.28	9.08	10.9	14.6	18.2	21.8
4.27	4.80	5.39	6.05	7.41	9.25	11.1	14.8	18.5	22.2
4.34	4.89	5.49	6.16	7.54	9.41	11.3	15.1	18.8	22.6
4.42	4.98	5.59	6.27	7.68	9.58	11.5	15.4	19.2	23.0
4.50	5.06	5.69	6.38	7.81	9.75	11.8	15.6	19.5	23.4
4.58	5.15	5.79	6.49	7.95	9.92	12.0	15.9	19.8	23.9
4.66	5.24	5.89	6.60	8.09	10.1	12.2	16.2	20.2	24.3
4.74	5.33	5.99	6.72	8.23	10.3	12.4	16.5	20.5	24.7
4.82	5.43	6.10	6.83	8.37	10.4	12.6	16.7	20.9	25.1
4.90	5.52	6.20	6.95	8.52	10.6	12.8	17.0	21.3	25.5
4.99	5.61	6.30	7.07	8.66	10.8	13.0	17.3	21.6	26.0
5.07	5.70	6.41	7.18	8.80	11.0	13.2	17.6	22.0	26.4
5.16	5.80	6.52	7.30	8.95	11.2	13.5	17.9	22.3	26.9
5.24	5.90	6.62	7.42	9.10	11.4	13.7	18.2	22.7	27.3
5.33	5.99	6.73	7.54	9.25	11.5	13.9	18.5	23.1	27.7
5.41	6.09	6.84	7.67	9.40	11.7	14.1	18.8	23.5	28.2
5.50	6.19	6.95	7.79	9.55	11.9	14.4	19.1	23.8	28.6
5.59	6.28	7.06	7.91	9.70	12.1	14.6	19.4	24.2	29.1
5.67	6.38	7.17	8.04	9.85	12.3	14.8	19.7	24.6	29.5
5.76	6.48	7.28	8.17	10.0	12.5	15.1	20.0	25.0	30.0
5.85	6.59	7.40	8.29	10.2	12.7	15.3	20.3	25.4	30.5
5.94	6.69	7.51	8.42	10.3	12.9	15.5	20.6	25.8	31.0
6.03	6.79	7.63	8.55	10.5	13.1	15.8	21.0	26.2	31.4
6.13	6.89	7.74	8.68	10.6	13.3	16.0	21.3	26.5	31.9
6.22	7.00	7.86	8.81	10.8	13.5	16.2	21.6	26.9	32.4
6.31	7.10	7.98	8.94	11.0	13.7	16.5	21.9	27.4	32.9
6.41	7.21	8.10	9.08	11.1	13.9	16.7	22.2	27.8	33.4
6.50	7.31	8.22	9.21	11.3	14.1	17.0	22.6	28.2	33.9
6.60	7.42	8.34	9.34	11.5	14.3	17.2	22.9	28.6	34.4
6.69	7.53	8.46	9.48	11.6	14.5	17.5	23.2	29.0	34.9
6.79	7.64	8.58	9.62	11.8	14.7	17.7	23.6	29.4	35.4
6.89	7.75	8.70	9.76	12.0	14.9	18.0	23.9	29.8	35.9
6.98	7.86	8.83	9.89	12.1	15.1	18.2	24.3	30.3	36.4
7.08	7.97	8.95	10.0	12.3	15.3	18.5	24.6	30.7	36.9
7.18	8.08	9.08	10.2	12.5	15.6	18.8	24.9	31.1	37.4

4 • extruded shapes





Runout table serving huge hydraulic extrusion press

manufacturing methods: Aluminum extruded shapes are produced by subjecting heated cast billets to sufficient hydraulic pressure to force the metal through a die of the desired cross-section. Forces of several million pounds are often used in extruding aluminum.

The heated billet is placed in the cylinder and pressure is applied to it by the hydraulic ram. Since the ram has considerable clearance in the cylinder in order to reduce friction, a disk (dummy block) having little clearance is placed between the ram and the billet to form a seal, thus preventing by-passing of metal around the ram.

The aluminum is forced through the die orifice by pressure applied through the hydraulic ram. The section emerging from the die has the dimensions and shape of the orifice. Speeds, pressures, and temperatures involved in extruding various alloys are closely controlled to insure uniform quality.

When the extrusion is completed, the die is removed from the end of the cylinder and a shear severs the extruded shape from the butt of the billet, which is discarded. The shape then is usually annealed or heat treated. It is in most cases straightened by stretching or roll straightening, but is usually not cold finished.

alloys and tempers: Extruded shapes are produced commercially by Reynolds in the following alloys and tempers:

NON-HEAT TREATABLE ALLOYS

alloys	tempers
2S, 3S, 52S	O, *F

*F (as fabricated) temper varies between soft and half-hard.

HEAT TREATABLE ALLOYS

alloys	tempers
17S, 24S	O, T
14S, R353, R361	O, T, W
R303	O, T275, T315

sections and sizes: The prime advantage of the use of extrusions lies in the flexibility of the process. Inasmuch as the dies for this process are not expensive, relatively small quantities of material can be extruded economically. Aluminum, due to its good workability and other

favorable properties, can be economically extruded to more intricate shapes, and larger sizes, than is practicable with many other metals. Therefore, designers are not limited to the use of conventional standard shapes shown in handbooks, but are warranted in originating shapes which will better fulfill the requirements of their particular application. American Standard shapes have found favor for many structural applications, but since these were designed primarily for steel, a modified section is sometimes preferable for aluminum, due to the fact that aluminum and steel have different deflection characteristics. Extruded shapes are produced in very simple, as well as extremely complex sections, and are used for a wide variety of applications. Many shapes are used to replace sections formerly built up, thereby saving time and labor and reducing costs.

Reynolds produces extruded shapes having cross-sectional areas as great as 12½ square inches and maximum dimensions across the section of 10 inches. Present manufacturing facilities usually limit the maximum length of extruded shapes to 50 feet and the maximum weight per piece to 350 pounds. If extruded shapes not conforming to these size ranges are desired, please contact our nearest Sales Office for information regarding the possibility of special exceptions to these limits.

lengths: Aluminum extruded shapes are usually ordered to one of the following length classifications:

EXACT LENGTHS: All pieces cut to specified length with a plus tolerance of ⅛ inch for lengths up to 10 feet; ¼ inch for lengths 10-30 feet; and ½ inch for lengths over 30 feet.

MULTIPLE LENGTHS: Pieces cut, at mill convenience, to any multiple of length specified with length tolerances same as for Exact Lengths. Note: Sufficient length for subsequent saw cuts should be included in the multiple specified.

RANDOM LENGTHS: Lengths will vary as follows:

MAXIMUM THICKNESS Inches	ACCEPTABLE LENGTH Feet
Up thru .374	8 — 12
.375 — 1.999	8 — 16
2.000 — 3.499	6 — 18
3.500 and up	3 — 18

identification: Standard marking of extruded shapes consists of stamping the alloy, temper and Reynolds trademark at approximate 6 inch intervals along the shape length with a non-corroding ink. Additional marking according to customer's specifications may be requested.

packing: Unless otherwise specified, aluminum extruded shapes of compact section are spirally wrapped with several thicknesses of suitable wrapping material, with boots on the ends. Fragile shapes and long lengths are packed in wooden or corrugated cardboard boxes. Package weights vary with the size and contour of the shape, but usually are limited to 250 pounds maximum.

Special packing for export shipment or according to customer specifications will require special consideration.

ordering data: All orders for aluminum extruded shapes should include the following:

Quantity

Alloy and temper

Section (our die number or a print showing complete dimensions)

Length Classification

compositions

34 • SPECIFIED CHEMICAL

ALLOY	SILICON		IRON	COPPER		MANGANESE		MAGNESIUM	
	Min	Max	Max	Min	Max	Min	Max	Min	Max
2S	....	....	1.0*	....	.20	....	.10	....	....
3S	....	.60	.70	....	.20	1.0	1.5	....	....
14S	.50	1.2	1.0	3.9	5.0	.40	1.2	.20	.80
17S	....	.80	1.0	3.5	4.5	.40	1.0	.20	.80
24S	....	.50	.50	3.8	4.9	.30	.90	1.2	1.8
52S	....	....	.45*	....	.10	....	.10	2.2	2.8
R303	....	.50	.50	.80	1.8	....	.10	2.1	3.0
R353	45-65% of Magnesium		.35	....	.10	....	.10	1.1	1.4
R361	.40	.80	.70	.15	.40	....	.15	.80	1.2

* Iron plus Silicon.

† Maximum of .25 Zinc and .15 Titanium permitted in Forging Stock.

COMPOSITIONS

CHROMIUM		ZINC	TITANIUM	OTHERS		ALUMINUM
Min	Max	Max	Max	EACH Max	TOTAL Max	
.....	.....	.10	.....	.05	.15	99.0 min
.....	.....	.10	.....	.05	.15	Remainder
.....	.10	.25	†	.05	.15	Remainder
.....	.25	† .10	†	.05	.15	Remainder
.....	.25	.10	.....	.05	.15	Remainder
.15	.35	.10	.....	.05	.15	Remainder
.10	.35	7.1	.....	.05	.15	Remainder
.15	.35	.25	†	.05	.15	Remainder
.....	.35	.10	.15	.05	.15	Remainder

specified mechanical properties

35 • NON-HEAT TREATABLE (COMMON) ALLOYS

ALLOY AND TEMPER	ULTIMATE STRENGTH Lb/Sq In. Minimum	ELONGATION IN 2 INCHES Percent Minimum
2S		
2S-O	15,500	25
2S-F	(Note 1)	
3S		
3S-O	19,000	25
3S-F	(Note 1)	
52S		
52S-O	32,000	25
52S-F	(Note 1)	

Note 1: Except in the annealed (O temper) condition, the temper of non-heat treatable alloy shapes cannot be closely controlled, and will vary between soft and half-hard.

36 • HEAT TREATABLE (STRONG) ALLOYS

ALLOY AND TEMPER	LEAST THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		Tensile	Yield	
14S				
14S-O	.125 and up*	★35,000	......	12
14S-W	.125 and up*	50,000	32,000	12
14S-T	.125—.499	60,000	50,000	7
	.500—.749	†65,000	◐55,000	7
	.750 and up*	†68,000	◐58,000	7
14-S	* Up thru an area of 15 square inches. ★ Maximum. † 60,000 for shapes heat treated by purchaser. ◐ 50,000 for shapes heat treated by purchaser.			
17S				
17S-O	All sizes	*35,000	......	12
17S-T	All sizes	50,000	35,000	12
17-S	* Maximum.			
24S				
24S-O	All sizes	*35,000	......	12
24S-T	.050—.249	57,000	†42,000	12
	.250—.749	★60,000	†44,000	12
	.750—1.499	★65,000	†46,000	10
	1.500 and up ◐	★70,000	†52,000	10
24-S	* Maximum. ★ 57,000 for shapes heat treated by purchaser. † 38,000 for shapes heat treated by purchaser. ◐ Up thru an area of 10 square inches.			
R303				
R303-O	All sizes	*35,000	......	12
R303-T275	.040 — .600	75,000	70,000	7
	.601 and up	80,000	75,000	8
R303-T315	.040 — .600	70,000	65,000	7
	.601 and up	75,000	70,000	8
R303	* Maximum.			

specified mechanical properties

37 • HEAT TREATABLE (STRONG) ALLOYS

ALLOY AND TEMPER	LEAST THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		Ultimate	Yield	
R317				
R317-O	All Sizes	*35,000	......	12
R317-T	All Sizes	50,000	35,000	12
R317 *Maximum.				
R353				
R353-O	All sizes	*19,000	......	18
R353-F	All sizes	17,000	10,000	10
R353-W	All sizes	25,000	14,000	16
R353-T	All sizes	32,000	25,000	10
R353-T5	All sizes	22,000	16,000	10
R353 * Maximum.				
R361				
R361-O	All sizes	*22,000	......	20
R361-W	All sizes	26,000	16,000	16
R361-T	All sizes	38,000	35,000	10
R361 * Maximum.				

38 • COMMERCIAL TOLERANCES

DIMENSION Inches	TOLERANCE Inches Plus or Minus	
	Non-Heat Treated Shapes	Heat Treated Shapes
up to .125	.007	.010
.126- .500	.010	.015
.501- 1.000	.015	.020
1.001- 2.000	.017	.025
2.001- 3.000	.020	.030
3.001- 4.000	.025	.035
4.001- 5.000	.030	.040
5.001- 6.000	.035	.045
6.001- 7.000	.040	.050
7.001- 8.000	.045	.055
8.001- 9.000	.050	.060
9.001-10.000	.055	.065
10.001-11.000	.060	.070
11.001-12.000	.065	.080

angles: Angular tolerance is 2° plus or minus where thickness of thinnest leg is up thru .187 inch; 1½° for .188 inch and up.

radii: Radius tolerance is plus 1/64 inch for sharp corners and fillets; plus or minus 1/64 inch for any specified radius up thru .187 inch; plus or minus 10 percent for .188 inch radii and larger.

contour: Allowable deviation from specified contour is plus or minus .006 inch for curved surfaces with chords up thru 1.499 inches; .012 for 1.500-2.999; .020 for 3.000-4.999; .030 for 5.000 and up.

surface roughness: Maximum allowable depth of die marks, handling marks, polishing marks, etc. is: .0015 inch for section thicknesses up thru .063 inch; .002 for .064-.125; .0025 for .126-.188; .003 for .189-.250; .004 for .251 and up.

5 • roll formed

manufacturing methods: Roll formed shapes are produced by passing coiled or flat sheet through a series of roller dies which progressively form it into a shape of the desired contour.

sections and sizes: Shapes produced by roll forming are limited to those having a uniform section thickness. Reynolds has facilities for roll forming thicknesses of .006 inch thru .125 inch to produce sections having a depth as great as 4 inches. The maximum section width is limited to those that can be formed from sheet not exceeding 38 inches in width. The minimum radius that can be formed depends on the alloy, temper, section thickness and contour of the shape.

Forming rolls are available for producing many standard angles, channels, and other sections. Additional rolls are made when required. Please consult Reynolds nearest Field Service Office regarding availability of tools to produce shapes to fulfill your requirements.

alloys and tempers: Reynolds produces roll formed shapes in the following alloys and tempers:

NON-HEAT TREATABLE ALLOYS

alloys	tempers
2S, 3S, 52S	O, ¼ H, ½ H, ¾ H, H

HEAT TREATABLE ALLOYS

alloys	tempers
17S, 24S, Pureclad 24S	O, T
R301, R353, R361	O, W, T

lengths: Aluminum roll formed shapes are usually ordered to one of the following length classifications:

EXACT LENGTHS: All shapes are cut to the exact length specified, with a length tolerance of plus or minus ⅛ inch unless otherwise specified.

Lengths of R301, R353, and R361, in the T temper, are limited to 40 feet maximum. Other alloys and other tempers of these alloys can be produced in any length desired.

STANDARD 12-FOOT LENGTHS: A minimum of 80 percent by weight of the shapes are cut to lengths of 12 feet plus or minus ⅛ inch, and the remainder is furnished in Random lengths from 18 inches to 12 feet unless otherwise specified.

finishes: Unless otherwise specified, Reynolds Aluminum Roll Formed Shapes are supplied with a mill finish.

MILL FINISH: The surface appearance varies between bright and dull, depending on the alloy, temper, and other factors.

BUFFED FINISH: If requested, roll formed shapes can be buffed. The surface appearance of this finish is bright and uniform.

identification: Standard marking of roll formed shapes consists of stamping the alloy, temper, and part number on each shape with a non-corroding ink.

packing: Roll formed shapes that are carried in stock are packed in bundles containing ten stock length pieces (usually 12 feet), spirally wrapped with several thicknesses of suitable wrapping material. Bright finish decorative moulding is protected with a transparent coating that can be peeled off after installation. Industrial shapes are packed in the most suitable manner for shipment.

ordering data: All orders for aluminum roll formed shapes should include the following:

Quantity (in feet, pounds, or number of pieces)

Section (Reynolds die number or a print showing complete dimensions)

Length

Alloy and Temper

ALLOY		SILICON Min	SILICON Max	IRON Max	COPPER Min	COPPER Max	MANGANESE Min	MANGANESE Max
2S		...	...	1.0*	...	.20	...	.10
3S		...	.60	.70	...	.20	1.0	1.5
17S		...	.80	1.0	3.5	4.5	.40	1.0
24S		...	.50	.50	3.8	4.9	.30	.90
Pureclad 24S	Core	...	.50	.50	3.8	4.9	.30	.90
Pureclad 24S	Cladding	...	...	.70*	...	.10	...	.05
52S		...	...	.45*	...	.10	...	.10
R301	Core	.50	1.2	1.0	3.9	5.0	.40	1.2
R301	Cladding	.35	1.0	.60	...	.10	...	.75
R353		45%-65% of Magnesium		.35	...	.10	...	.10
R361		.40	.80	.70	.15	.40	...	.15

* Silicon plus iron.

COMPOSITIONS

MAGNESIUM		CHROMIUM		ZINC	TITANIUM	OTHERS		ALUMINUM
						EACH	TOTAL	
Min	Max	Min	Max	Max	Max	Max	Max	
..	..	..	..	.10	..	.05	.15	99.0 min
..	..	..	..	.10	..	.05	.15	Remainder
.20	.80	..	.25	.10	..	.05	.15	Remainder
1.2	1.8	..	.25	.10	..	.05	.15	Remainder
1.2	1.8	..	.25	.10	..	.05	.15	Remainder
..	..	..	..	.10	..	..	..	99.3 min
2.2	2.8	.15	.35	.10	..	.05	.15	Remainder
.20	.80	..	.25	.25	..	.05	.15	Remainder
.80	1.5	..	.35	.10	.10	.05	.15	Remainder
1.1	1.4	.15	.35	.25	..	.05	.15	Remainder
.80	1.2	..	.35	.10	.15	.05	.15	Remainder

specified mechanical properties

40 • NON-HEAT TREATABLE

ALLOY AND TEMPER	ULTIMATE STRENGTH Lb/Sq In. Minimum
2S	
2S-O	15,000 *
2S-¼H	14,000
2S-½H	16,000
2S-¾H	19,000
2S-H	22,000
3S	
3S-O	19,000 *
3S-¼H	17,000
3S-½H	19,500
3S-¾H	24,000
3S-H	27,000
52S	
52S-O	31,000 *
52S-¼H	31,000
52S-½H	34,000
52S-¾H	37,000
52S-H	39,000

★ Maximum.

(COMMON) ALLOYS

SECTION THICKNESS—Inches

.006"-.007"	.008"-.012"	.013"-.019"	.020"-.031"	.032"-.050"	.051"-.113"	.114"-.161"	.162"-.249"
ELONGATION IN 2 INCHES—Percent Minimum							
2S							
15	15	15	20	25	30	30	30
.....	....	3	4	6	8	9	9
.....	1	2	3	4	5	6	6
1	1	1	2	3	4	4	.....
1	1	1	2	3	4	4	.....
3S							
16	18	20	20	23	25	25	25
.....	....	3	4	5	6	7	8
.....	1	2	3	4	5	6	7
1	1	1	2	3	4	4	......
1	1	1	2	3	4	4	......
52S							
.....	15	15	18	20	20	20	20
.....	.....	4	5	5	7	9	9
.....	3	3	4	4	6	7	7
.....	3	3	3	4	4	4	......
.....	3	3	3	4	4	4	......

specified mechanical properties

41 • HEAT TREATABLE (STRONG) ALLOYS

ALLOY AND TEMPER	SECTION THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		Ultimate	Yield	
17S				
17S-O	.010— .249	*35,000	......	12
17S-T	.010— .020	58,000	34,000	15
	.021— .040	58,000	34,000	★17
	.041— .128	58,000	34,000	18
	.129— .249	58,000	34,000	15
17S	* Maximum. ★ 18% minimum elongation for developed widths less than 30″ wide.			
24S				
24S-O	.012— .249	*35,000	......	12
24S-T	.012— .020	64,000	42,000	10
	.021— .051	64,000	42,000	13
	.052— .128	64,000	42,000	15
	.129— .249	64,000	42,000	14
24S	* Maximum.			
PURECLAD 24S				
Pureclad 24S-O	.012— .032	*33,000	......	8
	.033— .063	*33,000	......	10
	.064— .249	*34,000	......	12
Pureclad 24S-T	.012— .020	59,000	39,000	10
	.021— .040	59,000	39,000	12
	.041— .063	59,000	39,000	13
	.064— .128	62,000	40,000	13
	.129— .249	62,000	40,000	11
24S	* Maximum.			

42 • HEAT TREATABLE (STRONG) ALLOYS

ALLOY AND TEMPER	SECTION THICKNESS Inches	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
		Ultimate	Yield	
R301				
R301-O	Up to .249	*30,000	......	16
R301-W	Up to .039 .040— .249	56,000 57,000	37,000 37,000	14 15
R301-T	Up to .039 .040— .249	63,000 64,000	56,000 57,000	7 8
R301 * Maximum.				
R353				
R353-O	.013— .032 .033— .128 .129— .249	*19,000 *19,000 *19,000	....	20 22 25
R353-W	.013— .032 .033— .050 .051— .249	28,000 28,000 28,000	16,000 16,000 16,000	12 15 20
R353-T	.013— .031 .032— .249	35,000 35,000	28,000 28,000	8 10
R353 * Maximum.				
R361				
R361-O	.010— .020 .021— .128 .129— .249	*22,000 *22,000 *22,000	....	14 16 18
R361-W	.010— .020 .021— .249	30,000 30,000	16,000 16,000	14 16
R361-T	.010— .020 .021— .249	42,000 42,000	35,000 35,000	8 10
R361 * Maximum.				

commercial tolerance

43 • SECTION THICKNESS

SECTION THICKNESS Inches	TOLERANCE* Inches Plus or Minus
.006-.017	.0015
.018-.036	.002
.037-.045	.0025
.046-.076	.003
.077-.096	.0035
.097-.108	.004
.109-.140	.0045
.141-.172	.006
.173-.203	.007
.204-.249	.009

*Applies to developed widths up thru 36 inches.

44 • DEVELOPED WIDTH OF SECTION

DEVELOPED WIDTH Inches		TOLERANCE* Inches Plus or Minus	
Over	Thru	SECTION THICKNESS .006"—.102"	SECTION THICKNESS .103"—.249"
¼	4	.03	.06
4	18	.06	.09
18	36	.09	.12

*Tolerance also applies to one edge flange or leg. All other width and depth tolerances are plus or minus .03 inch.

45 • ANGLES

SECTION THICKNESS Inches	TOLERANCE Degrees Plus or Minus
.006-.188	1
.189-.249	2

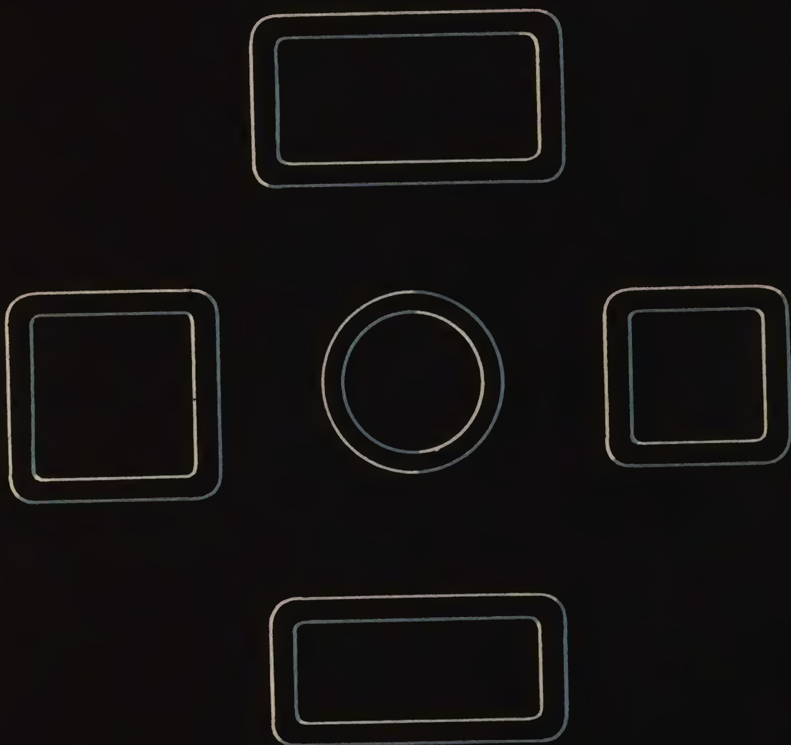
46 • RADIUS

RADIUS Inches	TOLERANCE Inches Plus or Minus
0.00-0.30	.01
0.31-1.00	.03
1.01-3.00	.06
3.01-6.00	.12

straightness: Sections will not vary in straightness in any part more than .12 inch in 12 feet except when such out-of-straightness (not to exceed .5 inch in 12 feet) can be corrected by hand pressure.

twist: Twist in any part of a section will not exceed the ratio of 2° to 12 feet of length except when such twist can be corrected by hand pressure.

6 • tubing and pipe



Working aluminum pipe at one of Reynolds Louisville plants

manufacturing methods: Reynolds Seamless Aluminum Tubing is produced by extruding cast ingots into tube blooms of a predetermined size, and cold drawing the blooms to tubes of closely controlled quality and dimensions.

A heated billet, placed in the cylinder of the extrusion press, is forced through the die orifice by pressure applied by the hydraulic ram. The outside diameter of the tube bloom is determined by the die orifice.

The mandrel, which extends through the billet and into the die orifice, controls the inside diameter. Since the ram has considerable clearance in the cylinder in order to reduce friction, a disk (dummy block) having very little clearance is placed between the ram and the billet to form a seal and prevent by-passing of metal around the ram. Speeds, pressures, and temperatures involved in extruding various alloys are closely controlled to insure uniform quality.

Cold drawing is employed to further control the dimensions and quality of tubing. The tube bloom is drawn through a series of dies conforming to the desired outside dimensions, while simultaneously the inside dimensions are governed by a mandrel or bulb. This operation imparts hardness and strength and is the means used to produce the cold worked tempers of non-heat treatable alloy tubing. Definite cold work tempers (¼H, ½H, etc.) can, however, only be furnished in round tubing, as the amount of cold work can not be accurately controlled in other sections. The effects of cold work can be removed by annealing to soften the material and, in the case of the heat treatable alloys, tubes can be further strengthened by heat treatment.

Round tube blooms can be cold drawn to produce a variety of sections by use of appropriate dies and bulbs.

alloys and tempers: Seamless aluminum tubing is produced commercially by Reynolds in the following alloys and tempers:

NON-HEAT TREATABLE GROUP

2S 3S 52S	O	
	¼H ½H ¾H H	round tubing only
	F	other tubing

HEAT TREATABLE GROUP

17S	O T
R353 R361	O W T

sizes and sections: ROUND TUBING AND PIPE: The most common forms of seamless aluminum tubing are round tubing and pipe. Reynolds has facilities for producing the range of commercial sizes shown on pages 132 to 135.

On pages 151 to 157, in connection with weight data, are sizes which are considered standard by many users of round aluminum tubing and pipe. If tubing outside the size range shown above is desired, please contact Reynolds' nearest Field Service Office for information regarding our ability to fulfill your requirements.

TUBING OTHER THAN ROUND: Seamless aluminum tubing is also produced in sections other than round, such as square, rectangular, hexagonal, octagonal, oval, elliptical, and many others. Reynolds has facilities for fabricating sections designed by users to meet their own special requirements. Reynolds tubing mill will gladly furnish information as to manufacturing limits and die costs, if any, for tubing other than round.

lengths: Aluminum tubing is usually ordered to one of the following length classifications:

EXACT LENGTHS: All tubes cut to the exact length as specified, with length tolerances as shown on page 142.

EXACT LENGTHS PLUS MILL ENDS (also referred to as STANDARD LENGTHS): A minimum of 85 percent by weight of tubes cut to the exact length specified and the remainder in Random lengths from 5 feet to the exact length specified. *Note:* This classification does not apply to specified lengths less than 5 feet.

RANDOM LENGTHS: Tubes will vary in length from 5 feet up to a length of 21 feet.

MULTIPLE LENGTHS: Tubes cut, at mill convenience, to any multiple of length specified, with length tolerances as shown on page 142. Multiples less than 6 inches will be cut Random. *Note:* Sufficient length for subsequent saw cuts should be included in the multiple specified.

COILS: Please contact our nearest Field Service Office for information regarding coiled tubing.

Reynolds has manufacturing facilities for producing tubing in straight lengths up to a maximum of 45 feet in the ¼H, ½H, ¾H and H tempers and in the heat treated (not artificially aged) condition. Straight

lengths of annealed, as well as artificially aged tubing, are limited to 40 feet.

finishes: Reynolds Seamless Aluminum Tubing is available in the following finishes:

MILL FINISH: The surface appearance varies between bright and dull, depending on the alloy, temper, and other factors. Tubing is usually supplied with a mill finish.

CAUSTIC DIP: This finish produces tubing of a uniform color and can be applied to tubing of any cross section in lengths not exceeding 12 feet.

identification: Standard marking consists of stamping the alloy, temper, and REYNOLDS at approximate 6 inch intervals along the tube length with a non-corroding ink. Additional marking or special marking according to customer's specifications may be requested.

Tubing too small for lettering will be tagged with the above information, or when requested, tubing may be identified by a 2 inch wide color stripe at each end and within 2 feet of the center of each length of tubing.

packing: Aluminum tubing is usually packed in wooden boxes in such manner as to prevent damage during normal handling. The weight of the package varies with the size of the tubing, but usually is limited to 250 pounds maximum. Different methods of protection are used in packing, depending upon the wall-diameter ratio and the temper of the tubing.

Requests for smaller packages, individual wrapping, interleaving, or extra protection for export shipment will be given careful consideration.

ordering data: All orders for aluminum tubing should include the following:

Quantity

Size (outside dimensions and wall thickness in decimals of an inch — nominal size for pipe)

Section (round, square, rectangular, etc.)

Alloy and Temper

Length Classification

WALL THICKNESS		MINIMUM OUTSIDE DIAMETER Inches	
Stubs' Gauge	Inches	2S, 3S, R353, R361	17S, 52S
....	.500	2 ¾	....
....	.484	2 ¾	....
....	.480	2 ½	....
....	.468	2 ½	....
....	.453	2 ½	....
....	.450	1 ½	2 ¼
....	.437	1 ½	2 ¼
....	.421	1 ½	2 ¼
....	.406	1 ½	2 ¼
....	.400	1 ½	2 ¼
....	.390	1 ½	2 ¼
....	.375	1 ⅜	2 ¼
....	.359	1 ⅜	2 ¼
....	.350	1 ⅜	1 ⅞
....	.344	1 ⅜	1 ⅞
....	.328	1 ⅜	1 ⅞
....	.320	1	1 ⅝
....	.312	1	1 ⅝
1	.300	⅞	1 ⅜
....	.297	⅞	1 ⅜
2	.284	⅞	1 ¼
....	.281	⅞	1 ¼
....	.266	⅞	1 ¼
3	.259	¾	1 ⅛
....	.250	¾	1 ⅛
4	.238	⅝	1
....	.234	⅝	1
5	.220	⅝	⅞
....	.218	⅝	⅞
6	.203	9/16	¾
....	.187	9/16	¾
7	.180	½	⅝

*Subject to change without notice.

TUBING

MAXIMUM OUTSIDE DIAMETER Inches				
2S-O, 2S-1/4H, 2S-1/2H, 3S-O, 3S-1/4H, 3S-1/2H, R353-O, R361-O	2S-3/4H, 3S-3/4H	2S-H, 3S-H	17S-O, 17S-T, R353-W, R353-T, R361-W, R361-T	52S-O
6	5	3¾	6	....
6	5¼	4	6	....
6	5¼	4	6	....
6	5½	4	6	....
6	5½	4¼	6	....
6	5½	4¼	6	3½
6	5½	4¼	6	3½
6	5½	4¼	6	3½
6	6	4½	6	3½
6	6	4½	6	3½
6	6	4½	6	3½
6	6	4¾	6	3½
6	6	5¼	6	3½
6	6	5¼	6	3½
6	6	5¼	6	3½
6	6	5½	6	3½
6	6	5½	6	3½
6	6	5½	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½

commercial sizes*

48 • ROUND

WALL THICKNESS		MINIMUM OUTSIDE DIAMETER Inches	
Stubs' Gauge	Inches	2S, 3S, R353, R361	17S, 52S
....	.171	½	⅝
8	.165	7/16	½
....	.156	7/16	½
9	.148	⅜	7/16
....	.140	⅜	7/16
10	.134	5/16	⅜
....	.125	5/16	⅜
11	.120	¼	5/16
12	.109	¼	¼
13	.095	¼	¼
....	.093	¼	¼
14	.083	3/16	3/16
....	.078	3/16	3/16
15	.072	3/16	3/16
16	.065	3/16	3/16
....	.062	3/16	3/16
17	.058	3/16	3/16
18	.049	⅛	⅛
....	.046	⅛	⅛
19	.042	⅛	⅛
20	.035	⅛	⅛
21	.032	⅛	⅛
22	.028	⅛	⅛
23	.025	⅛	⅛
24	.022	⅛	⅛
25	.020	⅛	⅛
26	.018	⅛	⅛
27	.016	⅛	⅛
28	.014	⅛	⅛
29	.013	⅛	⅛
30	.012	⅛	⅛
31	.010	⅛	⅛

*Subject to change without notice.

TUBING (continued)

MAXIMUM OUTSIDE DIAMETER Inches				
2S-O, 2S-1/4H, 2S-1/2H, 3S-O, 3S-1/4H, 3S-1/2H, R353-O, R361-O	2S-3/4H, 3S-3/4H	2S-H, 3S-H	17S-O, 17S-T, R353-W, R353-T, R361-W, R361-T	52S-O
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3⅛
6	6	6	6	3½
6	6	6	6	3½
6	6	6	6	3½
6	6	6	5	3½
6	6	6	3¾	3½
6	6	6	3¾	3½
5	5	5	3¼	3¼
4	4	4	2¾	2¾
4	4	4	2¾	2¾
3½	3½	3½	2½	2½
3	3	3	2	2
2¾	2¾	2¾	1⅜	1⅜
2½	2½	2½	9/16	9/16
1¼	1¼	1¼	7/16	7/16
1	1	1	3/8	3/8
1	1	1	5/16	5/16
5/8	5/8	5/8	1/4	1/4
9/16	9/16	9/16	3/16	3/16

49 • SPECIFIED CHEMICAL

ALLOY	SILICON		IRON	COPPER		MANGANESE	
	Min	Max	Max	Min	Max	Min	Max
2S	. . .	. . .	1.0*	. . .	.20	. . .	.10
3S	. . .	.60	.70	. . .	.20	1.0	1.5
17S	. . .	.80	1.0	3.5	4.5	.40	1.0
24S	. . .	.50	.50	3.8	4.9	.30	.90
52S	. . .	. . .	.45*	. . .	.10	. . .	.10
R353	45%-65% of Magnesium		.35	. . .	.10	. . .	.10
R361	.40	.80	.70	.15	.40	. . .	.15

* Iron plus Silicon.

COMPOSITION

Magnesium Min	Magnesium Max	Chromium Min	Chromium Max	Zinc Max	Titanium Max	Others Each Max	Others Total Max	Aluminum
. . .	. . .	. . .	. . .	.10	. . .	.05	.15	99.0 Min
. . .	. . .	. . .	. . .	.10	. . .	.05	.15	Remainder
.20	.80	. . .	.25	.10	. . .	.05	.15	Remainder
1.2	1.8	. . .	.25	.10	. . .	.05	.15	Remainder
2.2	2.8	.15	.35	.10	. . .	.05	.15	Remainder
1.1	1.4	.15	.35	.10	. . .	.05	.15	Remainder
.80	1.2	. . .	.35	.10	.15	.05	.15	Remainder

specified mechanical properties

50 • NON-HEAT TREATABLE (COMMON) ALLOYS			
ALLOY AND TEMPER	OUTSIDE DIAMETER Inches	WALL THICKNESS Inches	TENSILE STRENGTH Lb/Sq In. Minimum
2S			
2S-O	All sizes	All sizes	15,500 ★
2S-¼H	All sizes	All sizes	14,000
2S-½H	All sizes	All sizes	16,000
2S-¾H	All sizes	All sizes	19,000
2S-H	All sizes	All sizes	22,000
3S			
3S-O	All sizes	All sizes	19,000 ★
3S-¼H	All sizes	All sizes	17,000
3S-½H	All sizes	All sizes	19,500
3S-¾H	All sizes	All sizes	24,000
3S-H	All sizes	All sizes	27,000
52S			
52S-O	All sizes	All sizes	35,000 ★
52S-¼H	All sizes	All sizes	31,000
52S-½H	All sizes	All sizes	34,000
52S-¾H	All sizes	All sizes	37,000
52S-H	All sizes	All sizes	39,000

★ Maximum

51 • HEAT TREATABLE (STRONG) ALLOYS

ALLOY AND TEMPER	OUTSIDE DIAMETER Inches	STRENGTH Lb/Sq In.		ELONGATION IN 2 INCHES Percent Minimum			
		Ultimate	Yield	.018" to .024" wall	.025" to .049" wall	.050" to .259" wall	.260" to .500" wall
17S							
17S-O	All sizes	35,000*	....	..	..	..	..
17S-T	.250–2.000 2.001–8.000	55,000 55,000	40,000 † 40,000 †	.. ..	12 10	14 12	16 14
† 32,000 for tubing heat treated by the purchaser.							
24S							
24S-O	All sizes	35,000*	....	..	..	..	..
24S-T	.125–2.000 2.001–8.000	64,000 64,000	42,000 ‡ 42,000 ‡	10 ..	12 10	14 11	16 12
‡ 40,000 for tubing heat treated by the purchaser.							
R353							
R353-O	All sizes	19,000*	....	..	..	..	..
R353-W	.250–2.000 2.001–8.000	28,000 28,000	14,000 14,000	.. ..	16 14	18 16	20 18
R353-T	.250–2.000 2.001–8.000	35,000 35,000	28,000 28,000	.. ..	12 8	14 10	16 12
R361							
R361-O	All sizes	22,000*	....	..	..	..	..
R 361-W	.250–2.000 2.001–8.000	30,000 30,000	16,000 16,000	.. ..	16 14	18 16	20 18
R361-T	.250–8.000	42,000	35,000	..	8	10	10

★ Maximum

52 • DIAMETER

ROUND TUBING AND HEAT TREATABLE ALLOY PIPE				
NOMINAL DIAMETER (O.D. or I.D.) Inches	TOLERANCE[1]—Inches Plus or Minus			
	NON-HEAT TREATABLE (COMMON) ALLOYS		HEAT TREATABLE (STRONG) ALLOYS	
	MEAN[2] DIAMETER	INDIVIDUAL DIAMETER MEASUREMENT	MEAN[2] DIAMETER	INDIVIDUAL DIAMETER MEASUREMENT
.250- .500	.003	.003	.003	.006
.501- 1.000	.004	.004	.004	.008
1.001- 2.000	.005	.005	.005	.010
2.001- 3.000	.006	.006	.006	.012
3.001- 5.000	.008	.008	.008	.016
5.001- 6.000	.010	.010	.010	.020
6.001- 8.000	.015	.015	.015	.030
8.001-10.000	.020	.020	.020	.040
10.001-12.000	.025	.025	.025	.050

53 • WALL THICKNESS

NOMINAL WALL THICKNESS (T) Inches	TOLERANCE—Inches Plus or Minus		
	NON-HEAT TREATABLE (COMMON) ALLOYS	HEAT TREATABLE (STRONG) ALLOYS	
	INDIVIDUAL WALL THICKNESS MEASUREMENT	MEAN[4] WALL THICKNESS	INDIVIDUAL WALL THICKNESS MEASUREMENT
.010-.035	.002	.002	10% of T
.036-.049	.003	.003	10% of T
.050-.120	.004	.004	10% of T
.121-.203	.005	.005	10% of T
.204-.300	.008	.008	10% of T
.301-.375	.012	.012	10% of T
.376-.500	.032	.032	10% of T

TOLERANCES

NON-HEAT TREATABLE ALLOY PIPE			
PIPE SIZE Inches		TOLERANCE[3]	
ABOVE	THRU	OUTSIDE DIAMETER Inches Plus	INSIDE DIAMETER Inches Minus
....	½	.005	.003
½	2	.008	.005
2	4	.010	.007
4	6	.012	.008
6	8	.014	.009
8	10	.016	.012
....	....	....	....
....	....	....	....
....	....	....	....

NOTE 1: The diameter tolerances in Table 52 do not apply to thin-wall tubes (wall thickness less than 2.5% of O.D. or less than .020 inch), tubes in the soft (0) temper, and tubing produced in coils, all of which shall be commercially round.

NOTE 2: Mean diameter in Table 52 is the average of two diameter measurements taken at right angles to each other at any point along the length.

NOTE 3: In Table 52, if O.D. and wall or I.D. and wall are the controlling dimensions, the order should be entered as commercial round tubing and not as a pipe size, as the wall thickness of STANDARD and EXTRA-HEAVY PIPE is not guaranteed for tolerance.

NOTE 4: Mean wall thickness in Table 53 is the average of any two wall thickness measurements taken at 180 degrees from each other.

54 • LENGTH, ROUND TUBING AND PIPE

NOMINAL OUTSIDE DIAMETER Inches	TOLERANCE[5]—Inches Plus				
	LENGTHS UP THRU 2 Ft	LENGTHS OVER 2 Ft THRU 20 Ft	LENGTHS OVER 20 Ft THRU 30 Ft	LENGTHS OVER 30 Ft	COILED TUBING
Up to .250	1/8	1/4	3/8	1/2	3%
.251- 2.000	1/16	1/8	3/16	3/8	2%
2.001- 3.000	1/8	3/16	1/4	5/16	..
3.001-10.000	3/16	1/4	5/16	3/8	..
10.001-12.000	1/4	5/16	3/8	..	..

NOTE: A tolerance of $\frac{1}{64}$ inch per inch of O.D., or fraction thereof, will apply on the squareness of all saw cuts.

55 • STRAIGHTNESS, ROUND TUBING, PIPE

NOMINAL OUTSIDE DIAMETER Inches	TOLERANCE
.375 and up	one part in 1200 parts or .1 inch in 10 feet.

NOTE: The above straightness tolerance does not apply to tubing in the soft (0) temper or in diameters less than 3/8 inch, which shall be commercially straight and substantially free from kinks and short bends.

for tubing other than round

diameter: Diameter tolerances for round tubing apply to corresponding dimensions of tubing other than round with the following exceptions:

SQUARE AND RECTANGULAR TUBING: Tolerances for distance across flats, when measured at corners, shall be the same as for a round tube having a diameter equal to the specified dimensions. For square tubing, the tolerance for distance across flats, when measured at a distance from the corner, shall be double the tolerance for a round

tube having a diameter equal to the distance across flats of the square tube. For rectangular tubing, the tolerance for distance across flats, when measured at a distance from the corner, shall be double the tolerance for a round tube having a diameter equal to the dimension of the rectangular tube at right angles to the one being measured.

wall thickness: The wall thickness tolerance for tubing other than round shall be plus or minus 10 percent of the specified wall thickness.

length: Same as for round tubing.

straightness: Same as for round tubing.

twist: The twist tolerance for tubing other than round shall be ½ degree per foot of length. (Twist is the angular difference in position of the cross section at any two points along the length of the tube.)

angularity: The angularity tolerance on any angle formed by two adjacent straight sides of any tube having a wall thickness at least 2½ percent of the diameter of the equivalent round tube shall be plus or minus three degrees. The angles on tubes having a wall thickness less than 2½ percent of the diameter of the equivalent round shall be reasonably true.

radius: The radius tolerance shall be plus or minus 10 percent of the specified radius, with a minimum tolerance of plus or minus 1/64 inch. When square corners are specified a maximum radius of 1/64 inch shall be permitted.

56 • OVAL, ELLIPTICAL, STREAMLINE TUBING

OUTSIDE DIAMETER OF EQUIVALENT ROUND INCHES	MAJOR AXIS TOLERANCE		MINOR AXIS TOLERANCE	
	Inches Plus	Inches Minus	Inches Plus	Inches Minus
Up to 2.500	.040	.025	.025	.015
2.501-4.250	.050	.035	.035	.025
4.251-6.000	.070	.050	.055	.040
6.001 and up	Consult Mill			

pressure data

The internal pressure which seamless tubing and pipe may be expected to withstand may be estimated by use of the following formulas:

$$P_b = S\frac{D^2 - d^2}{D^2 + d^2} \qquad P_S = \frac{P_b}{F}$$

in which P_b = Internal bursting pressure in lb/sq in.

P_S = Safe internal pressure in lb/sq in.

S = Tensile strength in lb/sq in.

D = Outside diameter of tube in inches

d = Inside diameter of tube in inches

F = Factor of safety (such as 4 or 6)

In the following tables are values for $\frac{D^2 - d^2}{D^2 + d^2}$ and tensile strength at room temperature. To eliminate decimals, a factor of 1000 has been used in calculating the values.

EXAMPLE: Suppose it is desired to find the safe internal pressure for 1⅜" O.D. x .058" wall thickness 17S-T tubing, using a factor of safety (F) of 4.

The values obtained from the tables are:

$$S = 55 \text{ and } \frac{D^2 - d^2}{D^2 + d^2} = 88$$

Therefore, $P_b = 55 \times 88 = 4840$ lb/sq in.

and $P_S = 4840 \div 4 = 1210$ lb/sq in.

57 • TENSILE STRENGTH, 1000 Lb/Sq In.

TEMPER	COMMON ALLOYS			TEMPER	STRONG ALLOYS			
	2S	3S	52S		17S	24S	R353	R361
O	12	15	28					
¼H	14	17	31	O	26	26	15	18
½H	16	19.5	34	W	..	..	28	30
¾H	19	24	37	T	55	64	35	42
H	22	27	39					

58 • ALUMINUM PIPE - $\frac{D^2 - d^2}{D^2 + d^2}$ (In Thousandths)

PIPE SIZE Inches	STANDARD	EXTRA HEAVY	PIPE SIZE Inches	STANDARD	EXTRA HEAVY
⅛	388	560	2	138	200
¼	375	523	2½	151	210
⅜	304	436	3	131	186
½	292	406	3½	119	171
¾	238	334	4	111	161
1	222	308	4½	104	152
1¼	183	256	5	97	144
1½	164	232			

59 • ROUND TUBING, RATIO

WALL THICKNESS		OUTSIDE DIAMETER							
Stubs' Gauge	Inches	⅛	3⁄16	¼	5⁄16	⅜	7⁄16	½	⅝
	.450	..	..	..	..	..	..	..	..
	.400	..	..	..	..	..	..	..	..
	.375	..	..	..	..	..	..	..	..
	.350	..	..	..	..	..	..	..	..
	.320	..	..	..	..	..	..	..	..
1	.300	..	..	..	..	..	..	..	..
2	.284	..	..	..	..	..	..	..	..
3	.259	..	..	..	..	..	..	..	..
4	.238	..	..	..	..	..	..	..	924
5	.220	..	..	..	..	..	..	..	839
6	.203	..	..	..	..	..	..	..	781
7	.180	..	..	..	..	..	..	855	695
8	.165	..	..	..	..	..	886	793	636
9	.148	..	..	..	..	915	811	715	566
10	.134	..	..	..	960	849	739	646	508
11	.120	..	..	997	898	771	661	574	450
12	.109	..	..	968	832	702	598	517	404
13	.095	..	..	891	734	608	515	445	347
14	.083	..	974	797	640	526	444	383	299
15	.072	..	898	695	550	450	379	327	256
16	.065	..	828	625	491	402	339	292	229
17	.058	..	746	554	433	354	299	258	202
18	.049	911	629	460	359	294	248	215	169
19	.042	806	533	388	303	248	210	182	143
20	.035	676	436	317	248	204	173	150	118
21	.032	615	395	287	225	185	157	136	107
22	.028	533	341	248	195	160	136	118	94
23	.025	471	301	219	173	142	121	105	83
24	.022	409	261	191	151	124	106	92	73
25	.020	368	235	173	136	112	96	83	66
26	.018	327	210	154	122	101	86	75	59
27	.016	287	185	136	108	89	76	66	53
28	.014	248	160	118	94	77	66	58	46
29	.013	229	148	109	87	72	61	53	42
30	.012	210	136	101	80	66	56	49	39
31	.010	173	112	83	66	55	47	41	..

OF D^2-d^2 TO D^2+d^2, In Thousandths

—Inches

3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
..	..	..	..	..	..	724	668	618	574	536
..	..	..	..	..	..	642	590	545	505	471
..	..	..	..	..	658	600	550	508	471	438
..	..	..	..	..	612	557	511	471	436	406
..	..	771	687	615	556	505	463	426	395	368
..	820	725	652	574	518	471	431	397	368	342
..	781	685	606	541	488	443	405	374	346	322
825	715	623	549	489	440	400	366	337	313	291
764	656	569	501	446	401	364	333	307	285	265
708	604	523	459	409	368	334	306	282	261	243
652	554	478	420	374	336	306	280	258	239	223
574	485	419	368	327	295	268	245	226	210	196
523	441	380	334	297	268	243	223	206	191	178
464	391	337	296	264	238	216	198	183	170	159
415	350	302	266	237	213	194	178	165	153	143
368	310	268	235	210	190	172	158	146	136	127
331	279	241	212	189	171	156	143	132	123	115
284	240	208	183	163	148	135	124	114	106	99
245	207	180	158	142	128	117	107	99	92	86
210	178	154	136	122	110	101	93	86	80	75
188	159	138	122	109	99	90	83	77	72	67
166	141	123	108	97	88	80	74	68	64	60
139	118	103	91	81	74	67	62	58	54	50
118	101	88	77	69	63	58	53	49	46	43
98	83	72	64	58	52	48	44	41	38	36
89	76	66	59	53	48	44	40	37	35	33
77	66	58	51	46	41	38	35	33	30	28
69	58	51	45	41	37	34	31	29	27	25
60	52	45	40	36	33	30	27	25	24	22
55	47	41	36	32	30	27	25	23	22	20
49	42	37	32	29	27	24	22	21	19	18
44	37	33	29	26	..	..	..	..	..	..
38	33	28	..	..	..	..	..	..	..	..
35	30	26	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..

60 • ROUND TUBING, RATIO

WALL THICKNESS		OUTSIDE DIAMETER						
Stubs' Gauge	Inches	2 1/4	2 1/2	2 3/4	3	3 1/4	3 1/2	3 3/4
..	.500	..	..	424	385	352	324	301
..	.480	..	450	405	368	336	310	287
..	.450	471	419	377	342	313	289	268
..	.400	413	368	331	301	275	254	235
..	.375	385	342	308	280	257	237	220
..	.350	359	317	286	260	238	220	204
..	.320	323	287	259	235	216	199	185
1	.300	301	268	241	220	201	186	173
2	.284	283	252	227	207	190	175	163
3	.259	256	228	206	187	172	159	148
4	.238	233	208	188	171	157	145	135
5	.220	214	191	173	157	144	134	124
6	.203	196	175	158	144	133	123	114
7	.180	173	154	139	127	117	108	101
8	.165	157	141	127	116	107	99	92
9	.148	140	125	113	104	95	88	82
10	.134	126	113	102	93	86	79	74
11	.120	112	101	91	83	77	71	66
12	.109	102	91	82	75	69	64	60
13	.095	96	79	71	65	60	56	52
14	.083	77	69	62	57	52	49	45
15	.072	66	59	54	49	45	42	39
16	.065	59	53	48	44	41	38	35
17	.058	53	47	43	39	36	34	31
18	.049	44	40	36	33	31	28	26
19	.042	38	34	31	28	26	24	23
20	.035	32	28	26	24	22	20	19
21	.032	29	26	24	22	20	19	17
22	.028	25	23	21	19	17	16	15
23	.025	23	20	18	17	16	14	..
24	.022	20	18	16	15	..	..	..
25	.020	18	16	15	..	..	..	..
26	.018	16	15	..	..	..	..	..

OF $D^2 - d^2$ TO $D^2 + d^2$, In Thousandths

—Inches

4	4¼	4½	4¾	5	5¼	5½	5¾	6
280	262	246	232	220	208	198	189	180
268	251	235	222	210	199	190	181	173
250	234	220	207	196	186	177	169	161
220	206	193	182	173	164	156	149	142
205	192	180	170	161	153	146	139	133
190	178	167	158	150	142	135	129	123
173	162	152	144	136	129	123	117	112
161	151	142	134	127	121	115	110	105
152	142	134	127	120	114	109	104	99
138	129	122	115	109	104	99	94	90
126	118	111	105	100	95	90	86	82
116	109	103	97	92	87	83	79	76
107	100	94	89	84	80	77	73	70
94	88	83	79	75	71	68	65	62
86	81	76	72	68	65	62	59	57
77	72	68	64	61	58	55	53	51
69	65	61	58	55	52	50	48	46
62	58	55	52	49	47	45	43	41
56	53	50	47	45	42	40	39	37
49	46	43	41	39	37	35	34	32
42	40	38	36	34	32	31	29	28
37	34	33	31	29	28	27	25	24
33	31	29	28	26	25	24	23	22
29	28	26	25	23	22	21	20	20
25	23	22	21	20	19	18	17	16
21	20	19	18	17	16	15	15	14
18	17	16	15	14	..	..	..	..
16	..	..	..	..	..	..	..	..
14	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

Pouring pure molten aluminum into pig molds at Reynolds Listerhill plant

weights

The weight tables that follow are based on the density of 2S, which is .0979 pounds per cubic inch. If more accurate determination of weight for other aluminum alloys is desired, the applicable conversion factor should be used. Conversion factors for other metals and alloys are also shown for ready reference.

$$\text{Weight of} \left\{ \begin{array}{r} 3S = 1.01 \\ 17S = 1.03 \\ 24S = 1.02 \\ 52S = 0.98 \\ R301 = 1.00 \\ R353 = 0.993 \\ R361 = 0.996 \\ \\ \text{Brass} = 3.1 \\ \text{Copper} = 3.3 \\ \text{Nickel} = 3.26 \\ \text{Steel} = 2.89 \\ \text{Zinc} = 2.6 \end{array} \right\} \times \text{weight of 2S}$$

Weights shown for round tubing can be used to calculate the weight of square, hexagonal and octagonal tubing of uniform wall thickness by use of the appropriate conversion factor.

$$\text{weight of} \left\{ \begin{array}{r} \text{square tube} = 1.27 \\ \text{hexagonal tube} = 1.10 \\ \text{octagonal tube} = 1.06 \end{array} \right. \times \left\{ \begin{array}{l} \text{weight of round tube of same} \\ \text{wall thickness having diameter} \\ \text{equal to distance across flats of} \\ \text{tube under consideration.} \end{array} \right.$$

61 • ROUND TUBING —

WALL THICKNESS		OUTSIDE DIAMETER							
Stubs' Gauge	Inches	⅛	3/16	¼	5/16	⅜	7/16	½	⅝
..	.450	..	..	..	..	..	..	..	..
..	.400	..	..	..	..	..	..	..	..
..	.375	..	..	..	..	..	..	..	..
..	.350	..	..	..	..	..	..	..	..
..	.320	..	..	..	..	..	..	..	..
1	.300	..	..	..	..	..	..	..	..
2	.284	..	..	..	..	..	..	..	..
3	.259	..	..	..	..	..	..	..	..
4	.238	..	..	..	..	..	..	..	.340
5	.220	..	..	..	..	..	..	..	.329
6	.203	..	..	..	..	..	..	..	.316
7	.180	..	..	..	..	..	..	.213	.296
8	.165	..	..	..	..	..	.166	.204	.280
9	.148	..	..	..	..	.124	.158	.192	.261
10	.134	..	..	..	.0883	.119	.150	.181	.243
11	.120	..	..	.0576	.0853	.113	.141	.168	.224
12	.109	..	..	.0567	.0819	.107	.132	.157	.208
13	.095	..	..	.0543	.0763	.0982	.120	.142	.186
14	.083	..	.0320	.0512	.0703	.0894	.109	.128	.166
15	.072	..	.0307	.0473	.0639	.0805	.0971	.114	.147
16	.065	..	.0294	.0444	.0594	.0744	.0894	.104	.134
17	.058	..	.0277	.0411	.0536	.0679	.0812	.0946	.121
18	.049	.0137	.0250	.0364	.0477	.0590	.0703	.0816	.104
19	.042	.0129	.0226	.0322	.0419	.0516	.0613	.0710	.0904
20	.035	.0116	.0197	.0278	.0358	.0439	.0520	.0601	.0762
21	.032	.0110	.0184	.0257	.0331	.0405	.0479	.0553	.0700
22	.028	.0100	.0165	.0229	.0294	.0359	.0423	.0488	.0619
23	.025	.0092	.0150	.0208	.0265	.0323	.0381	.0438	.0554
24	.022	.0084	.0134	.0185	.0236	.0287	.0337	.0388	.0490
25	.020	.0078	.0124	.0170	.0216	.0262	.0308	.0354	.0447
26	.018	.0071	.0113	.0154	.0196	.0237	.0279	.0320	.0403
27	.016	.0064	.0101	.0138	.0175	.0212	.0249	.0286	.0360
28	.014	.0057	.0090	.0122	.0154	.0187	.0219	.0251	.0316
29	.013	.0054	.0084	.0114	.0144	.0174	.0204	.0234	.0293
30	.012	.0050	.0078	.0105	.0133	.0161	.0189	.0216	.0271
31	.010	.0042	.0066	.0089	.0112	.0135	.0158	.0181	..

Pounds Per Linear Foot

—Inches

3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2
..	..	..	..	..	..	1.74	1.95	2.16	2.37	2.57
..	..	..	..	..	..	1.62	1.81	1.99	2.18	2.36
..	..	..	..	..	1.38	1.56	1.73	1.90	2.08	2.25
..	..	..	..	..	1.32	1.49	1.65	1.81	1.97	2.13
..	..	.803	.951	1.10	1.25	1.39	1.54	1.69	1.84	1.98
..	.637	.776	.913	1.05	1.19	1.33	1.47	1.61	1.74	1.88
..	.619	.750	.882	1.01	1.14	1.27	1.41	1.54	1.67	1.80
.469	.589	.708	.828	.947	1.07	1.19	1.31	1.43	1.54	1.66
.450	.560	.669	.779	.889	.999	1.11	1.22	1.33	1.44	1.55
.430	.532	.633	.735	.836	.938	1.04	1.14	1.24	1.34	1.45
.410	.503	.597	.691	.784	.878	.972	1.07	1.16	1.25	1.35
.379	.462	.545	.628	.711	.794	.787	.960	1.04	1.13	1.21
.356	.432	.508	.585	.661	.737	.813	.889	.965	1.04	1.12
.329	.397	.465	.534	.602	.670	.739	.807	.875	.943	1.01
.305	.366	.428	.490	.552	.614	.676	.737	.799	.861	.923
.279	.334	.390	.445	.500	.556	.611	.667	.722	.777	.833
.258	.308	.358	.409	.459	.509	.560	.610	.660	.710	.761
.230	.273	.317	.361	.405	.449	.493	.536	.580	.624	.668
.204	.243	.281	.319	.357	.396	.434	.472	.511	.549	.587
.180	.213	.247	.280	.313	.346	.379	.413	.446	.479	.512
.164	.194	.224	.254	.284	.314	.344	.374	.404	.434	.464
.148	.175	.202	.228	.255	.282	.309	.335	.362	.389	.416
.217	.149	.172	.195	.217	.240	.262	.285	.308	.330	.353
.110	.129	.149	.168	.187	.207	.226	.245	.265	.284	.304
.0924	.109	.125	.141	.157	.173	.189	.205	.222	.238	.254
.0848	.100	.114	.129	.144	.159	.173	.188	.203	.218	.232
.0746	.0875	.100	.113	.126	.139	.152	.165	.178	.191	.204
.0669	.0784	.0900	.101	.113	.125	.136	.148	.159	.171	.182
.0591	.0693	.0794	.0896	.0997	.110	.120	.130	.140	.150	.161
.0539	.0631	.0723	.0816	.0908	.100	.109	.118	.128	.137	.146
.0486	.0569	.0652	.0735	.0818	.0901	.0985	.107	.115	.123	.132
.0433	.0507	.0581	.0655	.0729	..	..	..	..	..	..
.0380	.0445	.0509	..	..	..	..	..	..	..	..
.0354	.0414	.0474	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..	..	..

62 • ROUND TUBING —

WALL THICKNESS		OUTSIDE DIAMETER						
Stubs' Gauge	Inches	2¼	2½	2¾	3	3¼	3½	3¾
..	.500	..	..	4.15	4.61	5.07	5.54	6.00
..	.480	..	3.58	4.02	4.46	4.91	5.35	5.79
..	.450	2.99	3.40	3.82	4.24	4.65	5.07	5.48
..	.400	2.73	3.10	3.47	3.84	4.21	4.58	4.95
..	.375	2.60	2.94	3.29	3.63	3.98	4.33	4.67
..	.350	2.45	2.78	3.10	3.42	3.75	4.07	4.39
..	.320	2.28	2.57	2.87	3.17	3.46	3.76	4.05
1	.300	2.16	2.44	2.71	2.99	3.27	3.54	3.82
2	.284	2.06	2.32	2.58	2.85	3.11	3.37	3.63
3	.259	1.90	2.14	2.38	2.62	2.86	3.10	3.34
4	.238	1.77	1.99	2.21	2.43	2.65	2.87	3.08
5	.220	1.65	1.85	2.05	2.26	2.46	2.66	2.87
6	.203	1.53	1.72	1.91	2.10	2.28	2.47	2.66
7	.180	1.38	1.54	1.71	1.87	2.04	2.21	2.37
8	.165	1.27	1.42	1.57	1.73	1.88	2.03	2.18
9	.148	1.15	1.28	1.42	1.56	1.69	1.83	1.97
10	.134	1.05	1.17	1.29	1.42	1.54	1.66	1.79
11	.120	.943	1.05	1.16	1.28	1.39	1.50	1.61
12	.109	.861	.962	1.06	1.16	1.26	1.36	1.46
13	.095	.756	.643	.930	1.02	1.11	1.19	1.29
14	.083	.664	.740	.817	.894	.970	1.05	1.12
15	.072	.579	.645	.712	.778	.845	.911	.977
16	.065	.524	.584	.644	.704	.764	.824	.884
17	.058	.469	.523	.576	.630	.683	.737	.790
18	.049	.398	.443	.488	.534	.579	.624	.669
19	.042	.342	.381	.420	.459	.497	.536	.575
20	.035	.286	.318	.351	.383	.415	.448	.480
21	.032	.262	.291	.321	.351	.380	.410	.439
22	.028	.230	.255	.281	.307	.333	.359	.385
23	.025	.205	.228	.251	.274	.298	.321	..
24	.022	.181	.201	.222	.242	..	..	..
25	.020	.165	.183	.202	..	..	..	..
26	.018	.148	.165	..	..	..	..	..

Pounds Per Linear Foot

—Inches

4	4¼	4½	4¾	5	5¼	5½	5¾	6
6.46	6.92	7.38	7.84	8.30	8.77	9.23	9.69	10.1
6.24	6.68	7.12	7.56	8.01	8.45	8.89	9.34	9.78
5.90	6.31	6.73	7.14	7.56	7.97	8.39	8.80	9.22
5.31	5.68	6.05	6.42	6.79	7.16	7.53	7.90	8.27
5.01	5.36	5.71	6.06	6.40	6.75	7.09	7.44	7.79
4.71	5.04	5.36	5.68	6.01	6.33	6.65	6.98	7.30
4.35	4.64	4.94	5.23	5.53	5.82	6.12	6.41	6.71
4.10	4.37	4.65	4.93	5.20	5.48	5.76	6.03	6.31
3.90	4.16	4.42	4.68	4.94	5.21	5.47	5.73	5.99
3.58	3.82	4.05	4.29	4.53	4.77	5.01	5.25	5.49
3.30	3.52	3.74	3.96	4.18	4.40	4.62	4.84	5.06
3.07	3.27	3.48	3.68	3.88	4.08	4.29	4.49	4.69
2.84	3.03	3.22	3.41	3.59	3.78	3.97	4.16	4.34
2.54	2.70	2.87	3.04	3.20	3.37	3.53	3.70	3.87
2.34	2.49	2.64	2.79	2.94	3.10	3.25	3.40	3.55
2.10	2.24	2.38	2.51	2.65	2.79	2.92	3.06	3.20
1.91	2.04	2.16	2.28	2.41	2.53	2.65	2.78	2.90
1.71	1.83	1.94	2.05	2.16	2.27	2.38	2.49	2.60
1.57	1.67	1.77	1.87	1.97	2.07	2.17	2.27	2.37
1.37	1.46	1.54	1.63	1.72	1.81	1.90	1.98	2.07
1.20	1.28	1.35	1.43	1.51	1.58	1.66	1.74	1.81
1.04	1.11	1.18	1.24	1.31	1.38	1.44	1.51	1.58
.944	1.00	1.06	1.12	1.18	1.24	1.30	1.36	1.42
.844	.897	.951	1.00	1.06	1.11	1.16	1.22	1.27
.715	.760	.805	.850	.895	.941	.986	1.03	1.08
.614	.652	.691	.730	.769	.807	.846	.885	.924
.512	.544	.577	.609	.642	..	..	..	..
.469	..	..	..	..	..	..	..	..
.410	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..
..	..	..	..	..	..	..	..	..

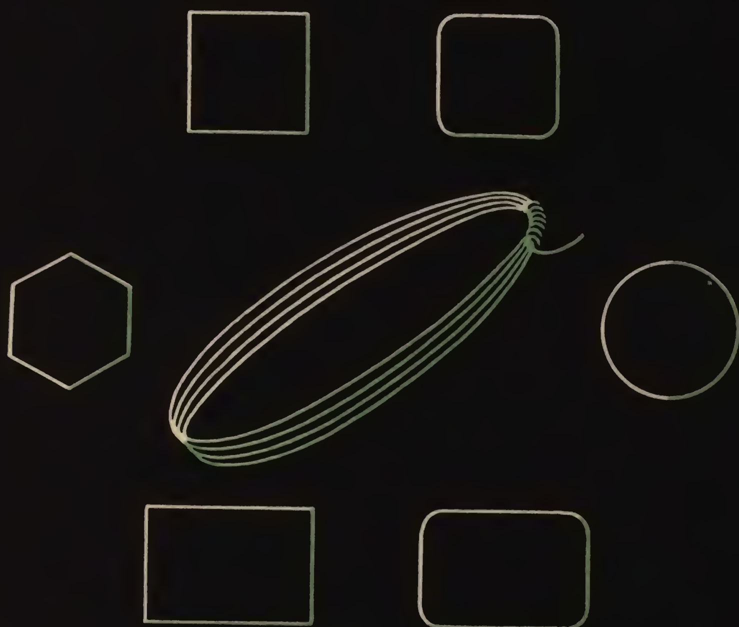
63 • ALUMINUM PIPE —

PIPE SIZE Inches	OUTSIDE DIAMETER Inches	STANDARD PIPE SIZES		
		INSIDE DIAMETER Inches	WALL THICKNESS Inches	WEIGHT Lb/Ft
⅛	.405	.269	.068	.0846
¼	.540	.364	.088	.147
⅜	.675	.493	.091	.196
½	.840	.622	.109	.294
¾	1.050	.824	.113	.391
1	1.315	1.049	.133	.580
1¼	1.660	1.380	.140	.785
1½	1.900	1.610	.145	.939
2	2.375	2.067	.154	1.26
2½	2.875	2.469	.203	2.00
3	3.500	3.068	.216	2.62
3½	4.000	3.548	.226	3.15
4	4.500	4.026	.237	3.73
4½	5.000	4.506	.247	4.33
5	5.563	5.047	.258	5.05

Pounds Per Linear Foot

EXTRA HEAVY PIPE SIZES		
INSIDE DIAMETER Inches	WALL THICKNESS Inches	WEIGHT Lb /Ft
.215	.095	.109
.302	.119	.185
.423	.126	.255
.546	.147	.376
.742	.154	.509
.957	.179	.750
1.278	.191	1.04
1.500	2.00	1.25
1.939	.218	1.74
2.323	.276	2.65
2.900	.300	3.54
3.364	.318	4.32
3.826	.337	5.18
4.290	.355	6.09
4.813	.375	7.18

7 • wire, rod and bar



Drawing aluminum alloy wire at
Reynolds Metals Plant 7, Louisville

definitions: Aluminum wire, rod, and bar are defined as follows:

WIRE is a solid section — such as a round, square, hexagon, octagon, or rectangle — of less than ⅜ inch greatest dimension.

ROD is a solid round section ⅜ inch or greater in diameter.

BAR is a solid section other than round — such as a square, hexagon, octagon, or rectangle — having greatest dimension ⅜ inch or over.

manufacturing methods: Reynolds produces wire, rod, and bar by rolling and extrusion. Rolling is usually employed, but some sizes may be extruded.

WIRE is produced by drawing rod through a series of progressively smaller dies to obtain the desired dimensions.

ROD AND BAR, NON-COLD FINISHED, are produced by hot working to final dimensions.

ROD AND BAR, COLD FINISHED, are produced by hot working to a size slightly larger than specified and reducing to final dimensions by cold working. Cold finished products have a better finish and closer dimensional tolerances than non-cold finished products.

alloys and tempers: Wire, rod, and bar are produced by Reynolds in the following alloys and tempers:

Wire	17S, 24S, R317	O and T tempers
	R353, R361	O, W, and T tempers
Rod and Bar	2S, 3S, 52S	O and F tempers
	17S, 24S, R317	O and T tempers
	R353, R361	O, W, and T tempers

sizes and sections: The range of commercial sizes and the standard size increments for wire, rod, and bar produced by Reynolds in the above alloys and tempers are as shown on page 164.

Reynolds Screw Machine Stock is produced in 17S-T rod and hexagonal bar in standard 12 foot lengths in the following sizes.

lengths: Aluminum wire, rod, and bar is usually ordered to one of the following length classifications:

RANDOM LENGTHS: In sizes up to 2 inches diameter or greatest distance across flats, lengths will vary from 8 to 16 feet; in sizes 3½ inches and over, lengths will vary from 3 to 18 feet.

Random lengths of 12 feet maximum can be supplied if shorter lengths are necessary. Mill lengths are considered preferable, however.

MILL LENGTHS: A minimum of 85 percent by weight will be furnished in one length within the range of 8 to 16 feet — the remainder in shorter Random lengths.

(Mill lengths have proven highly successful for use in automatic screw machines.)

STANDARD 12 FOOT LENGTHS: A minimum of 80 percent by weight will be furnished in 12 foot lengths, plus or minus ½ inch — the remainder in lengths 8 to 12 feet.

EXACT LENGTHS: All pieces will be cut to the ordered length, with a plus tolerance of ⅛ inch on sizes up to 3½ inches diameter or greatest distance across flats, and lengths up to 10 feet, and with a plus tolerance of ¼ inch on all other sizes and lengths.

MULTIPLE LENGTHS: All material will be cut, at mill convenience, to any multiple of the length specified, with length tolerances the same as shown for Exact lengths. *Note:* Sufficient length for subsequent saw cuts should be included in the multiple specified.

COILS: Consult mill.

identification: Unless other identification is specified, the alloy and temper is stenciled with metal stamps on the end of each Reynolds bar and rod having a diameter or distance across flats of 1 inch or more. Straight lengths of wire and the smaller sizes of bar and rod will either be painted on the end with an identifying color, or the bundles will be tagged with the alloy and temper.

Each coil of wire will bear a tag showing the size, alloy, temper, and lot.

packing: Wire, rod, and bar in sizes up to about 3 inches will usually be shipped in bundles of approximately 250 pounds. Annealed material in sizes 1 inch and under, and all other material up to and including ½ inch, will be packed in wood or high-strength corrugated boxes. Annealed material in sizes over 1 inch, and other material in sizes over ½ inch to approximately 3 inches, will be spirally wrapped with several thicknesses of suitable wrapping material, with boots on the ends. However, carload lots and through-truck shipments of strong alloys which are not boxed will be spot-wrapped in the case of sizes up to about 3 inches, and larger sizes will be loaded in bulk.

ordering data: All orders for wire, bars, and rods should include the following:

Quantity

Size (diameter or distance across flats in decimal or common fractions)

Alloy and Temper

Section (indicate whether rounds, squares, hexagons, etc., are desired)

Length Classification (for wire, indicate whether coiled or straightened lengths are desired)

Orders for special wire, bars, and rods should reference a drawing showing the exact dimensions desired, or should include a detailed description.

sizes*

64 • COMMERCIAL		
FORM	PRODUCT	FINISH
Round	WIRE	Drawn
	ROD	Cold Finished
		Non-Cold Finished
Hexagonal	BAR	Cold Finished
Rectangular Square Edge	BAR	Non-Cold Finished

*Subject to change without notice.
** Maximum size of 24S-T rod is 5½ inches diameter.
†Standard sizes are shown in weight tables.

SIZES

DIAMETER OF DISTANCE ACROSS FLATS Inches		
From	Thru	Standard Increments
.125	.374	1/64
.375	1.500	1/32
1.501	2.500	1/16
2.501	3.000	1/16
3.001	3.500	1/8
3.501	**8.000	1/4
.750	1.625	1/16
15/32 x 3/4	5/8 x 2 1/2	†

65 • SPECIFIED CHEMICAL									
ALLOY	SILICON		IRON	COPPER		MANGANESE		MAGNESIUM	
	Min	Max	Max	Min	Max	Min	Max	Min	Max
2S	..	..	1.0 *	..	.20	..	.10	..	..
3S	..	.60	.70	..	.20	1.0	1.5	..	..
17S	..	.80	1.0	3.5	4.5	.40	1.0	.20	.80
24S	..	.50	.50	3.8	4.9	.30	.90	1.2	1.8
52S	..	..	.45 *	..	.10	..	.10	2.2	2.8
R317	..	1.0	1.0	3.5	4.5	.40	1.0	.20	.80
R353	.45–.65% of Magnesium		.35	..	.10	..	.10	1.1	1.4
R361	.40	.80	.70	.15	.40	..	.15	.80	1.2

*Iron plus Silicon.

COMPOSITIONS

CHROMIUM		LEAD		BISMUTH		ZINC	TITANIUM	OTHERS		ALUMINUM
								EACH	TOTAL	
Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	
..	..	..	..	..	..	.10	..	.05	.15	99.0 Min.
..	..	..	..	..	..	.10	..	.05	.15	Remainder
..	.25	..	..	..	..	.10	..	.05	.15	Remainder
..	.25	..	..	..	..	.10	..	.05	.15	Remainder
.15	.35	..	..	..	..	.10	..	.05	.15	Remainder
..	.25	.30	.70	.30	.70	.10	..	.05	.15	Remainder
.15	.35	..	..	..	..	.25	..	.05	.15	Remainder
..	.35	..	..	..	..	.10	.15	.05	.15	Remainder

specified mechanical properties

66 • NON-HEAT TREATABLE (COMMON) ALLOYS

FORM	TEMPER	TENSILE STRENGTH Lb/Sq In. Minimum	ELONGATION IN 2 INCHES Percent Minimum
2S			
Wire	2S-O	15,500 *	....
	2S-¼H	14,000	....
	2S-½H	16,000	....
	2S-¾H	19,000	....
	2S-H	22,000	....
Bar and Rod	2S-O	15,500 *	25
	2S-F	†	
3S			
Wire	3S-O	19,000 *	....
	3S-¼H	17,000	....
	3S-½H	19,500	....
	3S-¾H	27,000	....
	3S-H	27,000	....
Bar and Rod	3S-O	19,000 *	25
	3S-F	†	
52S			
Wire	52S-O	32,000 *	....
	52S-¼H	31,000	....
	52S-½H	34,000	....
	52S-¾H	37,000	....
	52S-H	39,000	....
Bar and Rod	52S-O	32,000 *	25
	52S-F	†	

*Maximum.

†Except in the annealed (O) condition, the temper of common alloy bars and rods cannot be closely controlled, and will vary according to size. An approximate indication as to these (As Fabricated) tempers for various sizes and sections is shown in the table below.

SECTION	DIAMETER OR LEAST DISTANCE ACROSS FLATS Inch	APPROXIMATE TEMPER		
		ROLLED	EXTRUDED	COLD FINISHED
Rounds Squares, Hexagons	Up to ¾	½H	⅛H to ¼H	½H to ¾H
	¾ to 1½	¼H to ½H	⅛H to ¼H	½H to ¾H
	1½ to 3	¼H	⅛H to ¼H	¼H to ½H
	3 to 8	⅛H to ¼H		⅛H to ¼H
Rectangles	Up to ⅛	¼H to ½H	⅛H to ¼H	½H to ¾H
	⅛ to ½	¼H to ½H	⅛H to ¼H	½H
	½ to 1½	¼H	⅛H to ¼H	¼H
	1½ to 3	⅛H to ¼H	⅛H to ¼H	⅛H to ¼H

67 • HEAT TREATABLE (STRONG) ALLOYS

FORM	TEMPER	SIZE	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES
			ULTIMATE	YIELD	Percent Minimum
17S					
Wire	17S-O	Up thru .124 .125 and up	35,000 * 35,000 *	....	 16
	17S-T	Up thru .124 .125 and up	55,000 55,000	 32,000	 14
Bar and Rod	17S-O	All sizes	35,000 *	....	16
	17S-T	All sizes	55,000	32,000	12
24S					
Wire	24S-O	Up thru .124 .125 and up	35,000 * 35,000 *	....	 16
	24S-T	Up thru .124 .125 and up	62,000 62,000	 40,000	 12
Bar and Rod	24S-O	All sizes	35,000 *	....	16
	24S-T	All sizes	62,000	40,000	12
R317					
Wire	R317-O	Up thru .124 .125 and up	35,000 * 35,000 *	....	 16
	R317-T	Up thru .124 .125 and up	55,000 55,000	 32,000	 14
Bar and Rod	R317-O	All sizes	35,000 *	....	16
	R317-T	All sizes	55,000	32,000	12

* Maximum.

specified mechanical properties

68 • HEAT TREATABLE (STRONG) ALLOYS

FORM	TEMPER	SIZE	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
			ULTIMATE	YIELD	
R353					
Wire	R353-O	Up thru .124 .125 and up	19,000 * 19,000 *	....	 20
	R353-W	Up thru .124 .125 and up	25,000 25,000	 14,000	 18
	R353-T	Up thru .124 .125 and up	32,000 32,000	 25,000	 14
	R353-T61	Up thru .124 .125 and up	30,000 30,000	 20,000	 14
Bar and Rod	R353-O	All sizes	19,000 *	....	20
	R353-W	All sizes	25,000	14,000	18
	R353-T	All sizes	32,000	25,000	14
	R353-T61	All sizes	30,000	20,000	14
R361					
Wire	R361-O	Up thru .124 .125 and up	22,000 * 22,000 *	....	 18
	R361-W	Up thru .124 .125 and up	30,000 30,000	 14,000	 18
	R361-T	Up thru .124 .125 and up	42,000 42,000	 35,000	 10
Bar and Rod	R361-O	All sizes	22,000 *	....	18
	R361-W	All sizes	30,000	14,000	18
	R361-T	All sizes	42,000	35,000	10

* Maximum.

Roll straightening hexagon aluminum bar stock at Reynolds Plant 8, Louisville

commercial tolerances

69 • ROUND WIRE AND ROD

DIAMETER Inches	DRAWN WIRE	COLD FINISHED ROD	NON-COLD FINISHED ROD	
	TOLERANCE Inches Plus or Minus	TOLERANCE Inches Plus or Minus	TOLERANCE	
			Inches Plus	Inches Minus
Up to .035	.0005	......	......	......
.036- .064	.001	......	......	......
.065- .374	.0015	......	......	......
.375- .500	......	.0015	......	......
.501-1.000	......	.002	......	......
1.001-1.500	......	.0025	......	......
1.501-2.500	......	.004	......	......
2.501-3.499	......	......	.006	.006
3.500-5.000	......	......	1/32	1/64
5.001-8.000	......	......	1/16	1/32

70 • SCREW MACHINE STOCK

DIAMETER OR DISTANCE ACROSS FLATS Inches	TOLERANCE—Inches Plus or Minus	
	ROUND ROD	HEXAGONAL BAR
.750-1.000	.002	.0025
1.001-1.500	.0025	.003
1.501-2.000	.006	.0035
2.001-3.375	.008	......

71 • SQUARE, HEXAGONAL, OCTAGONAL WIRE, BAR

DISTANCE ACROSS FLATS Inches	DRAWN WIRE TOLERANCE Inches Plus or Minus	COLD FINISHED BAR TOLERANCE Inches Plus or Minus	NON-COLD FINISHED BAR TOLERANCE Inches Plus or Minus
Up to .064	.0015	......	......
.065- .374	.002	......	......
.375- .500	......	.002	......
.501-1.000	......	.0025	......
1.001-1.500	......	.003	......
1.501-1.625	......	.0035	......
1.626-2.000	......	......	.016
2.001-3.000	......	......	.020
3.001-4.000	......	......	.030

commercial tolerances

72 • RECTANGULAR

DRAWN WIRE AND COLD FINISHED BAR *					
Areas up thru 3 sq in.		Areas greater than 3 sq in.			
WIDTH OR THICKNESS Inches	TOLERANCE Inches Plus or Minus	THICKNESS Inches	THICKNESS TOLERANCE Inches Plus or Minus	WIDTH Inches	WIDTH TOLERANCE Inches Plus or Minus
Up to .064	.0015	Up to .250	.0025	2.000–4.000	1/32
.065- .500	.002	.251– .500	.0035	....	....
.501-1.000	.0025	.501– .750	.005	....	....
1.001-1.500	.003	.751–1.500	.008	....	....
1.501-3.000	.005	....	......	....	....

* Rectangles are classified as wire in widths up thru .374 inch.

WIRE AND BAR

NON-COLD FINISHED BAR

THICKNESS Inches	THICKNESS TOLERANCE Inches Plus or Minus	WIDTH Inches	WIDTH TOLERANCE Inches Plus or Minus
Up to .500	.006	Up to 1.500	1/64
.501– .750	.008	1.501–4.000	1/32
.751–1.000	.012	4.001–6.000	3/64
1.001–2.000	.016	6.001–10.000	1/16
2.001–3.000	.020	....	....

weights

The weight tables in this booklet are based on the density of 2S, which is .0979 pounds per cubic inch. If more accurate determination of weight for other aluminum alloys is desired, the applicable conversion factor should be used. Conversion factors for other metals and alloys are also shown for ready reference.

$$\text{Weight of} \left\{ \begin{array}{r@{\;=\;}l} 3S & 1.01 \\ 17S & 1.03 \\ 24S & 1.02 \\ 52S & 0.98 \\ R317 & 1.03 \\ R353 & 0.993 \\[1ex] \text{Brass} & 3.1 \\ \text{Copper} & 3.3 \\ \text{Nickel} & 3.26 \\ \text{Steel} & 2.89 \\ \text{Zinc} & 2.6 \end{array} \right\} \times \text{weight of 2S}$$

DIAMETER Inch	SECTION AREA Sq In.	WEIGHT Lb / Ft
73 • ROUND WIRE		
1/8	.012272	.0144
9/64	.015532	.0182
5/32	.019175	.0225
11/64	.023202	.0273
3/16	.027612	.0324
13/64	.032405	.0381
7/32	.037583	.0442
15/64	.043143	.0507
1/4	.049088	.0577
17/64	.055415	.0651
9/32	.062126	.0730
19/64	.069221	.0813
5/16	.076699	.0901
21/64	.084561	.0993
11/32	.092806	.109
23/64	.10143	.119
74 • ROUND ROD		
3/8	.11045	.130
13/32	.12962	.152
7/16	.15033	.177
15/32	.17257	.203
1/2	.19635	.231
17/32	.22166	.260
9/16	.24851	.292
19/32	.27688	.325

DIAMETER Inch	SECTION AREA Sq In.	WEIGHT Lb / Ft
ROUND ROD (Cont.)		
5/8	.30680	.360
21/32	.33824	.397
11/16	.37122	.436
23/32	.40574	.477
3/4	.44179	.519
25/32	.47937	.563
13/16	.51849	.609
27/32	.55914	.657
7/8	.60132	.706
29/32	.64504	.758
15/16	.69029	.811
31/32	.73708	.866
1	.78540	.923
1 1/32	.83526	.981
1 1/16	.88665	1.04
1 3/32	.93957	1.10
1 1/8	.99402	1.17
1 5/32	1.0500	1.23
1 3/16	1.1075	1.30
1 7/32	1.1666	1.37
1 1/4	1.2272	1.44
1 9/32	1.2893	1.51
1 5/16	1.3530	1.59
1 11/32	1.4182	1.67
1 3/8	1.4849	1.74
1 13/32	1.5532	1.82
1 7/16	1.6230	1.91
1 15/32	1.6943	1.99

DIAMETER Inch	SECTION AREA Sq In.	WEIGHT Lb /Ft
75 • ROUND ROD		
1 ½	1.7672	2.08
1 9/16	1.9175	2.25
1 ⅝	2.0739	2.44
1 11/16	2.2366	2.63
1 ¾	2.4053	2.83
1 13/16	2.5802	3.03
1 ⅞	2.7612	3.24
1 15/16	2.9483	3.46
2	3.1416	3.69
2 1/16	3.3410	3.93
2 ⅛	3.5466	4.17
2 3/16	3.7583	4.42
2 ¼	3.9761	4.67
2 5/16	4.2001	4.93
2 ⅜	4.4301	5.20
2 7/16	4.6664	5.48
2 ½	4.9088	5.77
2 9/16	5.1573	6.06
2 ⅝	5.4119	6.36
2 11/16	5.6727	6.66
2 ¾	5.9396	6.98
2 13/16	6.2126	7.30
2 ⅞	6.4918	7.63
2 15/16	6.7771	7.96
3	7.0686	8.30
3 ⅛	7.6699	9.01
3 ¼	8.2958	9.75
3 ⅜	8.9462	10.5
3 ½	9.6212	11.3
3 ¾	11.045	13.0
4	12.566	14.8
4 ¼	14.186	16.7

DIAMETER Inch	SECTION AREA Sq In.	WEIGHT Lb /Ft
ROUND ROD (Cont.)		
4 ½	15.904	18.7
4 ¾	17.721	20.8
5	19.635	23.1
5 ¼	21.648	25.4
5 ½	23.758	27.9
5 ¾	25.967	30.5
6	28.274	33.2
6 ¼	30.680	36.0
6 ½	33.183	39.0
6 ¾	35.785	42.0
7	38.485	45.2
7 ¼	41.283	48.5
7 ½	44.179	51.9
7 ¾	47.173	55.4
8	50.266	59.1
76 • HEXAGONAL BAR		
¾	.48714	.572
13/16	.57171	.672
⅞	.66305	.779
15/16	.76116	.894
1	.86603	1.02
1 1/16	.97767	1.15
1 ⅛	1.0961	1.29
1 3/16	1.2212	1.43
1 ¼	1.3532	1.59
1 5/16	1.4919	1.75
1 ⅜	1.6373	1.92
1 7/16	1.7896	2.10
1 ½	1.9486	2.29
1 9/16	2.1144	2.48
1 ⅝	2.2869	2.69

77 • RECTANGULAR BAR

Square Edge

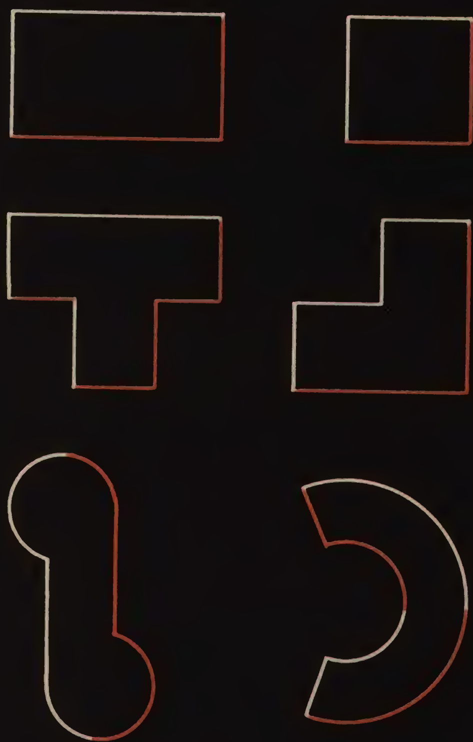
DISTANCE ACROSS FLATS Inches	SECTION AREA Sq In.	WEIGHT Lb/Ft
15/32 x 1/4	0.3516	0.4130
7/8	0.4102	0.4819
1	0.4687	0.5506
1 1/8	0.5273	0.6195
1 1/4	0.5859	0.6883
1 3/8	0.6445	0.7572
1 1/2	0.7031	0.8260
1 5/8	0.7617	0.8948
1 3/4	0.8203	0.9637
1 7/8	0.8789	1.032
2	0.9375	1.101
2 1/8	0.9961	1.170
2 1/4	1.0547	1.239
2 3/8	1.1133	1.308
2 1/2	1.1719	1.377
1/2 x 3/4	0.3750	0.4405
7/8	0.4375	0.5140
1	0.5000	0.5874
1 1/8	0.5625	0.6608
1 1/4	0.6250	0.7343
1 3/8	0.6875	0.8077
1 1/2	0.7500	0.8811
1 5/8	0.8125	0.9545
1 3/4	0.8750	1.028
1 7/8	0.9375	1.101
2	1.000	1.175
2 1/8	1.0625	1.248
2 1/4	1.1250	1.322
2 3/8	1.1875	1.395
2 1/2	1.2500	1.469

RECTANGULAR BAR (Cont.)

Square Edge

DISTANCE ACROSS FLATS Inches	SECTION AREA Sq In.	WEIGHT Lb/Ft
9/16 x 1	0.5625	0.6608
1 1/8	0.6328	0.7434
1 1/4	0.7031	0.8260
1 3/8	0.7734	0.9086
1 1/2	0.8437	0.9912
1 5/8	0.9141	1.074
1 3/4	0.9844	1.156
1 7/8	1.0547	1.239
2	1.1250	1.322
2 1/8	1.1953	1.404
2 1/4	1.2656	1.487
2 3/8	1.3359	1.569
2 1/2	1.4062	1.652
5/8 x 1	0.6250	0.7342
1 1/8	0.7031	0.8260
1 1/4	0.7812	0.9178
1 3/8	0.8594	1.010
1 1/2	0.9375	1.101
1 5/8	1.0156	1.193
1 3/4	1.0937	1.285
1 7/8	1.1719	1.377
2	1.2500	1.469
2 1/8	1.3281	1.560
2 1/4	1.4063	1.652
2 3/8	1.4844	1.744
2 1/2	1.5625	1.836

8 • forging stock



Loading forging stock for airplane propellers into preheating furnace

definitions: Aluminum alloy forging stock is available in a variety of forms to fulfill the diversified requirements of the forgings manufacturer. Definitions for the different forms are as follows:

FORGING ROD: Round forging stock having a diameter of ⅜ inch or more.

FORGING BAR: Forging stock of square or rectangular cross-section having a greatest distance across flats of ⅜ inch or more.

FORGING SHAPES: Forging stock having other than round, square, or rectangular cross-section.

Rod, bar, or shapes used for forging are rarely supplied in either the annealed or heat treated condition, and should always be identified as Forging Stock to avoid confusion with similar material used for other purposes.

manufacturing methods: Either of two basic manufacturing processes, rolling or extrusion, may be used to produce aluminum alloy forging stock. Forging shapes are usually extruded, but forging rod is nearly always rolled. Forging bar may be rolled or extruded. Material produced by either method may be cold finished to obtain close tolerances and to control the surface condition, or the material may be supplied hot finished, depending on requirements. In either case the forging stock is carefully conditioned and inspected to insure surfaces suitable for exacting forging requirements.

classes: Two classes of aluminum alloy forging bar and rod are produced. Class I forging stock is hot finished in most cases and is satisfactory for general forging use. Class II forging stock is cold finished to closer tolerances and is used for applications requiring close volume control. Forging shapes are produced only in Class I.

alloys: The alloys in which forging stock is produced and the characteristics of the material after forging and heat treatment are as follows:

ALLOY	CHARACTERISTICS
14S	High strength and relatively good forgeability.
17S	Good strength, corrosion resistance and machinability.
18S	Good properties at elevated temperatures.
25S	Ease of forging, good strength, and fair corrosion resistance.
32S	Good properties at elevated temperatures and low coefficient of expansion.

A51S	Ease of forging of large or intricate parts not requiring high strength. Better resistance to corrosion than 17S.
R317	Good strength, corrosion resistance, and excellent machinability.
R353	Excellent corrosion resistance, moderate strength, and good weldability.

Forging stock is designated only by the alloy, since a temper symbol is not affixed until after forging and heat treatment. All of the above alloys require heat treatment in addition to forging to develop optimum characteristics. Minimum mechanical properties of heat treated forgings are shown on page 187.

lengths: Aluminum alloy forging stock is usually ordered to one of the following classifications:

RANDOM LENGTHS: In accordance with the following table.

DIAMETER OR GREATEST DISTANCE BETWEEN PARALLEL FACES Inches	ACCEPTABLE LENGTH — Feet 80% min.	20% max.
⅜ to 2	8-16	3
2 to 3½	6-18	3
3½ and up	3-18	1½

EXACT LENGTHS: All material cut to specified length with the following tolerances:

DIAMETER OR GREATEST DISTANCE BETWEEN PARALLEL FACES Inches	TOLERANCE — Inches Plus Lengths up thru 10 feet	Lengths over 10 feet
Up to 3½	⅛	¼
3½ and over	¼	¼

MULTIPLE LENGTHS: Material cut to any convenient multiple of length specified within the Random length limits shown above. (Sufficient length for saw cuts should be included in the multiple specified.)

packing: Unless otherwise specified, forging stock in sizes up to approximately 3 inches is shipped in bundles weighing about 250

pounds. If shipment is made in carload lots or by through-truck, the bundles are spot wrapped. When considerable handling in shipment is anticipated, bundles are spirally wrapped with several thicknesses of suitable wrapping material and the ends protected by boots. Larger sizes may be loaded in bulk.

ordering data: Orders for aluminum alloy forging stock should include the following:

Quantity

Size (diameter or distance across flats for forging rod and bar — our die number or a print showing complete dimensions for shapes)

Section (indicate whether round, square, rectangle or shape)

Alloy (no temper designation is used for forging stock)

Class (except forging shapes)

Length Classification

EXAMPLE: 20,000 lbs. 2 inch dia. round 17S Forging Stock Class 2 in Random Lengths.

Orders for forging stock may reference specifications for finished forgings, in which case material conforming to the chemical requirements of the specification will be supplied. Specifications for other commodities do not apply to forging stock and should not be referenced.

sections and sizes: Round forging rod is used for the production of most forgings and pressings. However, there are instances in which some of the blocking operations can be eliminated by using one of the other forms. In the following table, and in the weight tables on pages 193 to 197, are shown forging stock sizes which are considered standard by many users and for which facilities are available for manufacturing in production quantities.

identification: Forging stock is supplied with the alloy number stamped (with metal stamps) on one end of the piece if the size permits. In addition, the alloy number, month of manufacture, the words "Forging Stock," and the name "Reynolds" is printed on the length of the forging stock near the ends. Material is tagged with this information if the size is such that it is impractical to stamp or stencil. Other identification may be supplied upon request.

sizes*

78 • COMMERCIAL SIZES				
SECTIONS	DIAMETER OR DISTANCE ACROSS FLATS—Inches			
	FROM	THRU	STANDARD INCREMENTS	
			Class I	Class II
Round Forging Rod	3/8	1 1/2	1/16	1/32
	1 1/2	3	1/16	1/16
	3**	3 1/2	1/8	
	3 1/2	8	1/4	
Rectangular Forging Bar	15/32 x 3/4	5/8 x 2 1/2	†	
Forging Shapes	Up thru maximum cross-sectional area of 12 1/2 sq in. providing shape cross-section can be enclosed within a 10 in. diameter circle.			

** Minimum size for 32S.
† Standard sizes are shown in weight tables.

Large squares having 3/4 inch corner flats are also available in random, multiple, and exact lengths up to a maximum of 96 inches in the alloys and sizes shown at right. Longer lengths may be supplied upon request, with mill approval.

ALLOYS	SIZES — Inches
14S 17S 32S A51S	4 3/8 x 4 3/8 5 3/8 x 5 3/8 6 x 6 7 x 7 7 5/8 x 7 5/8 9 1/8 x 9 1/8
18S 25S	4 1/2 x 4 1/2 5 1/2 x 5 1/2 6 x 6 7 x 7 7 3/4 x 7 3/4 9 1/4 x 9 1/4

*Subject to change without notice.

79 • AFTER FORGING AND HEAT TREATMENT

ALLOY AND TEMPER	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
	Ultimate	Yield	
14S-W	55,000	30,000	16
14S-T	65,000	50,000	10
17S-T	55,000	30,000	16
18S-T	55,000	40,000	10
25S-T	55,000	30,000	16
32S-T	52,000	40,000	5
A51S-T	44,000	34,000	12
R317-T	55,000	30,000	16
R353-T	36,000	30,000	14

80 • SPECIFIED CHEMICAL

ALLOY	SILICON		IRON	COPPER		MANGANESE		MAGNESIUM		CHROMIUM	
	Min	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max
14S	.50	1.2	1.0	3.9	5.0	.40	1.2	.20	.80	...	.10
17S	...	.80	1.0	3.5	4.5	.40	1.0	.20	.80	...	.25
18S	...	.90	1.0	3.4	4.5	...	.20	.45	.90	...	.10
25S	.50	1.2	1.0	3.9	5.0	.40	1.2	...	.05	...	.10
32S	11.0	13.5	1.0	.50	1.3	...	.20	.80	1.3	...	.10
A51S	.60	1.2	1.0	...	.35	...	.20	.45	.80	.15	.35
R317	...	1.0	1.0	3.5	4.5	.40	1.0	.20	.80	...	.25
R353	45-65% of Magnesium		.35	...	.10	...	.10	1.1	1.4	.15	.35

COMPOSITIONS

NICKEL		LEAD		BISMUTH		TITANIUM	ZINC	OTHERS		ALUMINUM
								EACH	TOTAL	
Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	
...	...	...	...	...	...	.15	.25	.05	.15	Remainder
...	...	...	...	...	...	.15	.25	.05	.15	Remainder
1.7	2.3	...	...	...	...	.15	.25	.05	.15	Remainder
...	...	...	...	...	...	.15	.25	.05	.15	Remainder
.50	1.3	...	...	...	...	.15	.25	.05	.15	Remainder
...	...	...	...	...	...	.15	.25	.05	.15	Remainder
...	...	.30	.70	.30	.70	.15	.25	.05	.15	Remainder
...	...	...	...	...	...	.15	.25	.05	.15	Remainder

commercial tolerances

81 • ROUND FORGING ROD

CLASS I			CLASS II		
DIAMETER Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches	DIAMETER Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches
.375-1.000	.015	1/64	**.375- .500**	.0015	.005
1.001-3.000	.015	1/32	**.501-1.000**	.002	.008
3.001-5.000	.031	1/16	**1.001-1.500**	.0025	.012
5.001-8.000	.063	3/32	**1.501-3.000**	.008	.015

*Conditioning allowance is an additional tolerance at localized areas to permit removal of possible surface defects.

82 • RECTANGULAR

CLASS I					
THICKNESS Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches	WIDTH Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches
.365- .500	.010	1/32	**Up to 1.500**	.018	1/16
.501-1.000	.015	1/32	**1.501- 4.000**	.031	1/16
1.001-2.000	.018	1/32	**4.001- 6.000**	.047	1/16
2.001-3.000	.020	1/32	**6.001-10.000**	.063	1/16
3.001-4.000	.031	1/32	....	....	....

*Conditioning allowance is an additional tolerance at localized areas to permit removal of possible surface defects.

83 • SQUARE FORGING BAR

CLASS I			CLASS II		
DISTANCE ACROSS FLATS Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches	DISTANCE ACROSS FLATS Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches
.375- .500	.010	1/32	.375- .500	.002	.005
.501-1.000	.015	1/32	.501-1.000	.0025	.008
1.001-2.000	.018	1/32	1.001-1.500	.003	.012
2.001-3.000	.020	1/32	1.501-3.000	.005	.015
3.001-4.000	.031	1/32	....	....	....

*Conditioning allowance is an additional tolerance at localized areas to permit removal of possible surface defects.

FORGING BAR

CLASS II		
THICKNESS OR WIDTH Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches
.375- .500	.002	.005
.501-1.000	.0025	.008
1.001-1.500	.003	.012
1.501-3.000	.005	.015
....	....	....

84 • FORGING SHAPES

CLASS I

DIMENSION Inches	TOLERANCE Inches Plus or Minus	CONDITIONING ALLOWANCE* Inches
up to .125	.007	1/32
.126- .500	.010	1/32
.501- 1.000	.015	1/32
1.001- 2.000	.017	1/32
2.001- 3.000	.020	1/32
3.001- 4.000	.025	1/32
4.001- 5.000	.030	1/32
5.001- 6.000	.035	1/32
6.001- 7.000	.040	1/32
7.001- 8.000	.045	1/32
8.001- 9.000	.050	1/32
9.001-10.000	.055	1/32
10.001-11.000	.060	1/32
11.001-12.000	.065	1/32

* Conditioning allowance is an additional tolerance at localized areas to permit removal of possible surface defects.

weights

The weight tables in this booklet are based on the density of 2S, which is .0979 pounds per cubic inch. If more accurate determination of weight for other aluminum alloys is desired, the applicable conversion factor should be used. Conversion factors for other metals and alloys are also shown for ready reference.

$$\text{weight of} \left\{ \begin{array}{c} \text{14S} - 1.03 \\ \text{17S} - 1.03 \\ \text{18S} - 1.03 \\ \text{25S} - 1.03 \\ \text{32S} - \ \ .993 \\ \text{A51S} - \ \ .993 \\ \text{R317} - 1.03 \\ \text{R353} - \ \ .993 \\ \\ \text{brass} - 3.1 \\ \text{copper} - 3.3 \\ \text{nickel} - 3.26 \\ \text{steel} - 2.89 \\ \text{zinc} - 2.6 \end{array} \right\} \times \text{weight of 2S}$$

DIAMETER Inches	SECTION AREA Sq In.	WEIGHT Lb /Ft
85 • ROUND ROD		
3/8	.11045	.130
13/32	.12962	.152
7/16	.15033	.177
15/32	.17257	.203
1/2	.19635	.231
17/32	.22166	.260
9/16	.24851	.292
19/32	.27688	.325
5/8	.30680	.360
21/32	.33824	.397
11/16	.37122	.436
23/32	.40574	.477
3/4	.44179	.519
25/32	.47937	.563
13/16	.51849	.609
27/32	.55914	.657
7/8	.60132	.706
29/32	.64504	.758
15/16	.69029	.811
31/32	.73708	.866

DIAMETER Inches	SECTION AREA Sq In.	WEIGHT Lb /Ft
ROUND ROD (Cont.)		
1	.78540	.923
1 1/32	.83526	.981
1 1/16	.88665	1.04
1 3/32	.93957	1.10
1 1/8	.99402	1.17
1 5/32	1.0500	1.23
1 3/16	1.1075	1.30
1 7/32	1.1666	1.37
1 1/4	1.2272	1.44
1 9/32	1.2893	1.51
1 5/16	1.3530	1.59
1 11/32	1.4182	1.67
1 3/8	1.4849	1.74
1 13/32	1.5532	1.82
1 7/16	1.6230	1.91
1 15/32	1.6943	1.99
1 1/2	1.7672	2.08
1 9/16	1.9175	2.25
1 5/8	2.0739	2.44
1 11/16	2.2366	2.63

DIAMETER Inches	SECTION AREA Sq In.	WEIGHT Lb /Ft
86 • ROUND ROD		
1 ¾	2.4053	2.83
1 13/16	2.5802	3.03
1 ⅞	2.7612	3.24
1 15/16	2.9483	3.46
2	3.1416	3.69
2 1/16	3.3410	3.93
2 ⅛	3.5466	4.17
2 3/16	3.7583	4.42
2 ¼	3.9761	4.67
2 5/16	4.2001	4.93
2 ⅜	4.4301	5.20
2 7/16	4.6664	5.48
2 ½	4.9088	5.77
2 9/16	5.1573	6.06
2 ⅝	5.4119	6.36
2 11/16	5.6727	6.66
2 ¼	5.9396	6.98
2 13/16	6.2126	7.30
2 ⅞	6.4918	7.63
2 15/16	6.7771	7.96

DIAMETER Inches	SECTION AREA Sq In.	WEIGHT Lb /Ft
ROUND ROD (Conc.)		
3	7.0686	8.30
3 ⅛	7.6699	9.01
3 ¼	8.2958	9.75
3 ⅜	8.9462	0.5
3 ½	9.6212	11.3
3 ¼	11.045	13.0
4	12.566	14.8
4 ¾	14.186	16.7
4 ½	15.904	18.7
4 ¾	17.721	20.8
5	19.635	23.1
5 ¼	21.648	25.4
5 ½	23.758	27.9
5 ¾	25.967	30.5
6	28.274	33.2
6 ¼	30.680	36.0
6 ½	33.183	39.0
6 ¾	35.785	42.0
7	38.485	45.2
7 ¼	41.283	48.5
7 ½	44.179	51.9
7 ¾	47.173	55.4
8	50.266	59.1

Manipulating bar stock in a straightening machine

87 • RECTANGULAR BAR
Square Edge

DISTANCE ACROSS FLATS Inches	SECTION AREA Sq In.	WEIGHTS Lb /Ft
15/32 x 3/4	0.3516	0.4130
7/8	0.4102	0.4819
1	0.4687	0.5506
1 1/8	0.5273	0.6195
1 1/4	0.5859	0.6883
1 3/8	0.6445	0.7572
1 1/2	0.7031	0.8260
1 5/8	0.7617	0.8948
1 3/4	0.8203	0.9637
1 7/8	0.8789	1.032
2	0.9375	1.101
2 1/8	0.9961	1.170
2 1/4	1.0547	1.239
2 3/8	1.1133	1.308
2 1/2	1.1719	1.377
1/2 x 3/4	0.3750	0.4405
7/8	0.4375	0.5140
1	0.5000	0.5874
1 1/8	0.5625	0.6608
1 1/4	0.6250	0.7343
1 3/8	0.6875	0.8077
1 1/2	0.7500	0.8811
1 5/8	0.8125	0.9545
1 3/4	0.8750	1.028
1 7/8	0.9375	1.101
2	1.000	1.175
2 1/8	1.0625	1.248
2 1/4	1.1250	1.322
2 3/8	1.1875	1.395
2 1/2	1.2500	1.469

RECTANGULAR BAR
Square Edge (Conc.)

DISTANCE ACROSS FLATS Inches	SECTION AREA Sq In.	WEIGHTS Lb /Ft
9/16 x 1	0.5625	0.6608
1 1/8	0.6328	0.7434
1 1/4	0.7031	0.8260
1 3/8	0.7734	0.9086
1 1/2	0.8437	0.9912
1 5/8	0.9141	1.074
1 3/4	0.9844	1.156
1 7/8	1.0547	1.239
2	1.1250	1.322
2 1/8	1.1953	1.404
2 1/4	1.2656	1.487
2 3/8	1.3359	1.569
2 1/2	1.4062	1.652
5/8 x 1	0.6250	0.7342
1 1/8	0.7031	0.8260
1 1/4	0.7812	0.9178
1 3/8	0.8594	1.010
1 1/2	0.9375	1.101
1 5/8	1.0156	1.193
1 3/4	1.0937	1.285
1 7/8	1.1719	1.377
2	1.2500	1.469
2 1/8	1.3281	1.560
2 1/4	1.4063	1.652
2 3/8	1.4844	1.744
2 1/2	1.5625	1.836

9 • ingots

definitions: Aluminum pig is metal poured into molds from the reduction pots, without remelting. Usual weight of a pig is 50-60 pounds. An aluminum ingot is pig metal that has been remelted, often with alloying elements added to give a specified chemical composition. An ingot weighs from 3 to 32 pounds.

manufacturing methods: Reynolds aluminum ingots are produced in such a manner as to minimize inclusions and porosity. Uniform casting characteristics from shipment to shipment are assured. Castings made from Reynolds ingots will show a fine grained structure when normal foundry practice is employed.

chemical analysis: A guaranteed chemical analysis is provided with each shipment of ingots.

types: Metal available includes high purity aluminum pigs and ingots, foundry alloy ingots, notched aluminum ingots and special shapes for deoxidation applications in the steel industry, and ingots for extrusion purposes.

sizes: The 30-pound unnotched ingot currently being supplied measures approximately 27¾ inches long and 4¾ inches wide at base of the tapered cross section which is about 3⅞ inches high. The 3 to 4-pound notched or unnotched ingot is approximately 14 inches long, 1½ inches high. Other sizes can be supplied.

nominal chemical composition: Table 6A (page 38) shows nominal chemical composition of 15 of the more common sand-casting alloys. Table 6B (page 38) gives similar data on 13 of the most widely used permanent-mold casting alloys; Table 6C (page 40) covers 6 common die-casting alloys.

typical mechanical properties: Table 9 (page 48) lists typical mechanical properties (tension, compression, shear, fatigue, hardness)

for 25 of the more common sand-casting alloys. Table 10A (page 50) gives similar information on 15 of the common permanent-mold casting alloys; with Table 10B (page 50) covering 9 of the most widely employed die-casting alloys.

densities and expansions: Table 11B (page 52) enumerates density and expansion values for 16 sand-casting alloys with Table 12A (page 54) including data on 6 more. Table 12B (page 54) gives similar information on 15 of the common permanent-mold casting alloys; with Table 12C (page 54) covering 10 die-casting alloys.

thermal and electrical conductivity: Values of thermal and electrical conductivity for sand-casting alloys appear in Table 14A (page 58); for permanent-mold casting alloys, in Table 14B (page 58); for die-casting alloys, in Table 14C (page 60).

identification: Each foundry ingot is stamped with a heat number and alloy identification. A detailed chemical analysis is supplied with each heat number.

packing: Small ingots are bundled and steel strapped into convenient shipping units. In carload shipments of more than a single alloy, the different alloys are carefully segregated for easy identification on receipt.

ordering data: When ordering pigs or ingots, the following information should be included:

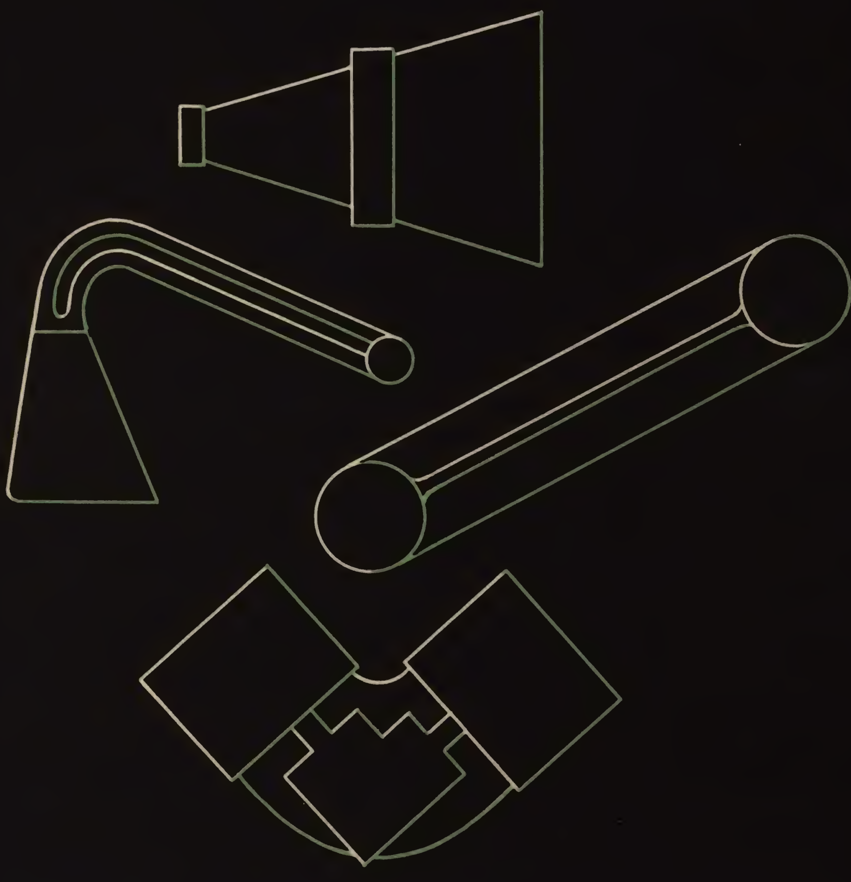
— Alloy: If standard, specify alloy number; if other than standard, chemical composition should be given.

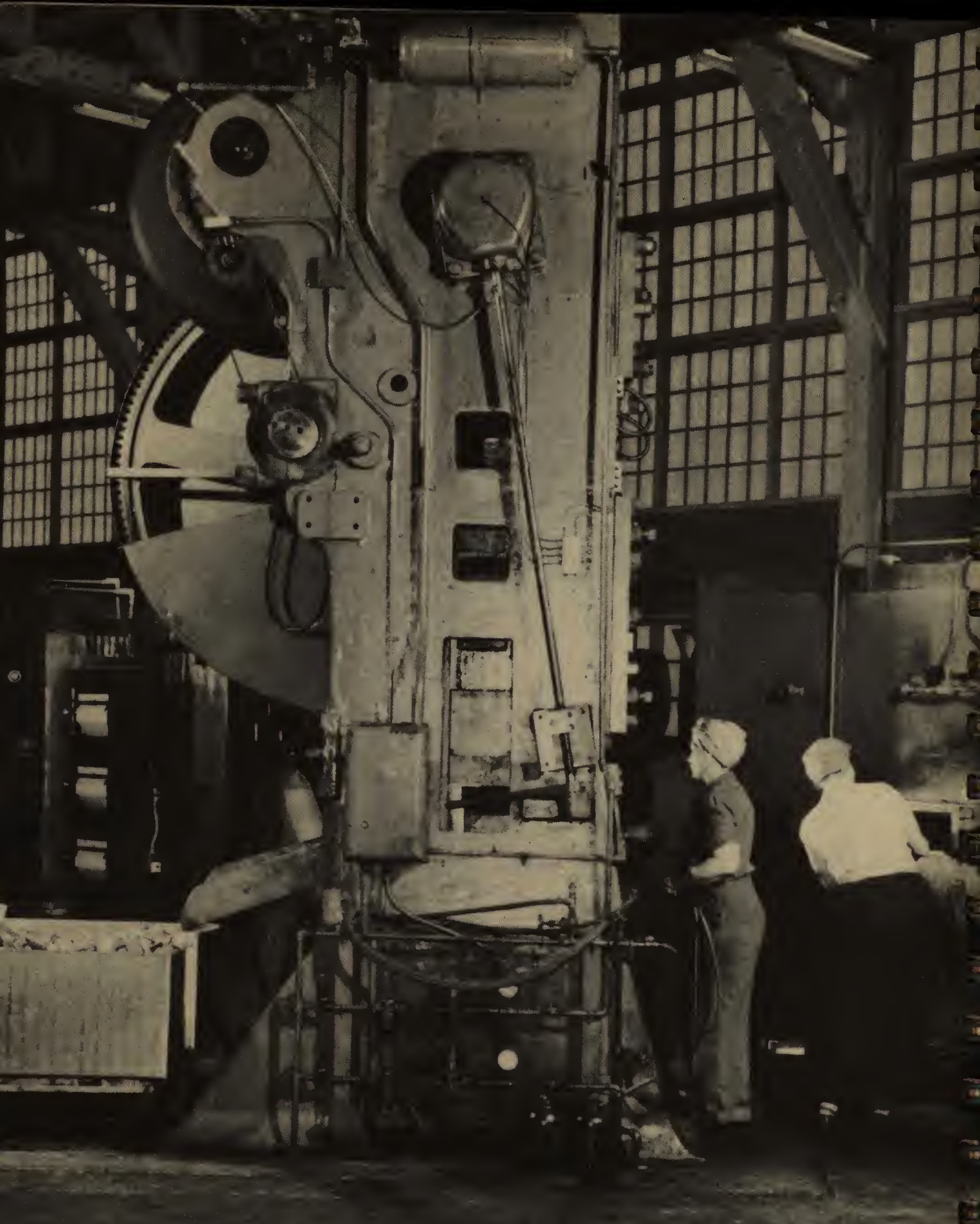
— Quantity

— Size and approximate weight of units

— Delivery date, shipping schedule and routing

10 • forgings





Hot forging aluminum aircraft parts in a Reynolds plant

alloys and tempers: Press forgings are produced by Reynolds in the following alloys and tempers:

NON-HEAT TREATABLE ALLOYS		HEAT TREATABLE ALLOYS	
2S, 3S, 52S	O and F tempers	17S, R317	T temper
		14S, 18S, 25S, 32S, A51S, R353, R361	W and T tempers
		R303	T275 and T315 tempers

sizes: Reynolds produces press forgings in sizes up thru 30 square inches cross-sectional area in the forging plane (at the parting line) and 6½ inches thick perpendicular to the forging plane which can be contained in a die with face dimensions of 7 by 16 inches. Under certain conditions, much larger limits can be accommodated.

identification: Standard marking of press forgings consists of a raised part number, Reynolds trademark, and the die set number.

packing: Reynolds forgings are packed in paper lined wooden boxes.

ordering data: All orders for aluminum press forgings should include the following:

Quantity

Alloy and Temper

Print showing exact design, dimensions, and tolerances.

design service: Reynolds Engineering Department will gladly furnish forging designs, if provided with a sample part, "machined" print or dimensional description along with necessary data detailing mechanical loading and chemical exposure to which the part will be subjected.

88 • SPECIFIED CHEMICAL

ALLOY	SILICON		IRON	COPPER		MANGANESE		MAGNESIUM		CHROMIUM	
	Min	Max	Max	Min	Max	Min	Max	Min	Max	Min	Max
14S	.50	1.2	1.0	3.9	5.0	.40	1.2	.20	.80	. .	.10
17S	. .	.80	1.0	3.5	4.5	.40	1.0	.20	.80	. .	.25
18S	. .	.90	1.0	3.4	4.5	. .	.20	.45	.90	. .	.10
25S	.50	1.2	1.0	3.9	5.0	.40	1.2	. .	.05	. .	.10
32S	11.0	13.5	1.0	.50	1.3	. .	.20	.80	1.3	. .	.10
A51S	.60	1.2	1.0	. .	.35	. .	.20	.45	.80	.15	.35
R303	. .	.50	.50	.80	1.8	. .	.10	2.1	3.0	.10	.35
R317	. .	1.0	1.0	3.5	4.5	.40	1.0	.20	.80	. .	.25
R353	45–65% of Mg		.35	. .	.10	. .	.10	1.1	1.4	.15	.35

* Minimum Zinc in R303 is 5.9 percent.

COMPOSITIONS

NICKEL		LEAD		BISMUTH		TITANIUM	ZINC	OTHERS		ALUMINUM
								EACH	TOTAL	
Min	Max	Min	Max	Min	Max	Max	Max	Max	Max	
..	..	..	..	..	..	.15	.25	.05	.15	Remainder
..	..	..	..	..	..	.15	.25	.05	.15	Remainder
1.7	2.3	..	..	..	..	.15	.25	.05	.15	Remainder
..	..	..	..	..	..	.15	.25	.05	.15	Remainder
.50	1.3	..	..	..	..	.15	.25	.05	.15	Remainder
..	..	..	..	..	..	.15	.25	.05	.15	Remainder
.05	.20	..	..	..	..	..	7.1 *	.05	.15	Remainder
..	..	.30	.70	.30	.70	.15	.25	.05	.15	Remainder
..	..	..	..	..	..	.15	.25	.05	.15	Remainder

89 • SPECIFIED MECHANICAL PROPERTIES

ALLOY AND TEMPER	STRENGTH Lb/Sq In. Minimum		ELONGATION IN 2 INCHES Percent Minimum
	Ultimate	Yield	
14S-W	55,000	30,000	16
14S-T	65,000	50,000	10
17S-T	55,000	30,000	16
18S-T	55,000	40,000	10
25S-T	55,000	30,000	16
32S-T	52,000	40,000	5
A51S-T	44,000	34,000	12
R317-T	55,000	30,000	16
R353-T	36,000	30,000	14
R303-T275	74,000	68,000	10
R303-T315	70,000	65,000	10

radii: Fillet and corner radii should be designed as large as practicable, thereby increasing die life and in many cases decreasing number of forging operations required.

draft angles: A draft angle tolerance of plus or minus 1° for all outside surfaces, inside holes, ribs, etc. is allowed, with the usual draft angle being 7°.

90 • SHRINKAGE *

DIMENSION (Any Direction) Inches	SHRINKAGE TOLERANCE Inches	
	Plus	Minus
1	.004	.002
2	.008	.004
3	.012	.006
4	.016	.008
5	.020	.010
6	.024	.012
For each additional inch, add	.004	.002

* Applies to unrestrained forgings only.

commercial tolerances

91 • THICKNESS

WEIGHT—Pounds		COMMERCIAL TOLERANCES	
Over	Thru	Inches Minus	Inches Plus
0.0	0.25	.010	.032
0.251	1.0	.015	.032
1.01	4.0	.032	.045
4.01	17.0	.032	.062
17.01	24.0	.032	.078
24.01	and up	.032	.093

Any closer tolerances will require additional operations, such as coining or cold re-striking, involving extra dies.

Thickness tolerances must be applied separately and independently of any other tolerance.

92 • STRAIGHTNESS

LENGTH OR WIDTH Inches		TOLERANCE—Inches	
Over	Thru	Commercial	Close
0	9	.016	.010
9	18	.031	.015
18	30	.047	.030
30	45	.063	.040
45	60	.094	.050
60	80	.125	.060

Any closer tolerances will require additional operations.

Straightness tolerances should be applied separately and independently of any other tolerances.

93 • MISMATCHING

WEIGHT—Pounds		TOLERANCE Inches
Over	Thru	
0	2.50	.015
2.50	6.25	.018
6.25	8.50	.021
8.50	15.00	.024
15.00	20.00	.028
20.00	25 and up	.032

rivets

sizes: Standard rivets can be supplied in sizes up to 3/16-inch shank diameter, not exceeding 1 inch in length.

alloys: Rivets are available in various alloys, including 17S, A17S, 24S, 2S, R353.

ordering data: All orders for aluminum alloy rivets should include the following information:

Quantity
Alloy
Temper (annealed; heat treated; aged; as fabricated)
Finish
Type Head
Type Shank
Complete Dimensions and Tolerances

other cold headed products, special rivets: For special rivets and other cold headed products, refer inquiries to Forging Division, Reynolds Metals Company, 2000 South Ninth Street, Louisville, Ky.

Elaborate mechanical testing facilities are important factor in process control at Reynolds

11 • reference tables

94 • COMPARISON OF GAUGES

Gauge No.	American or Brown & Sharpe's	Birm'ghan or Stubs'	Washburn & Moen	Imperial (British) S. W. G.	London or Old English	United States Standard
7/0	......	....	.4900	.500	....	.500
6/0	.5800	....	.4615	.464	....	.46875
5/0	.5165	....	.4305	.432	....	.4375
4/0	.4600	.454	.3938	.400	.454	.40625
3/0	.4096	.425	.3625	.372	.425	.375
2/0	.3648	.380	.3310	.348	.380	.34375
0	.3249	.340	.3065	.324	.340	.3125
1	.2893	.300	.2830	.300	.300	.28125
2	.2576	.284	.2625	.276	.284	.265625
3	.2294	.259	.2437	.252	.259	.25
4	.2043	.238	.2253	.232	.238	.234375
5	.1819	.220	.2070	.212	.220	.21875
6	.1620	.203	.1920	.192	.203	.203125
7	.1443	.180	.1770	.176	.180	.1875
8	.1285	.165	.1620	.160	.165	.171875
9	.1144	.148	.1483	.144	.148	.15625
10	.1019	.134	.1350	.128	.134	.140625
11	.09074	.120	.1205	.116	.120	.125
12	.08081	.109	.1055	.104	.109	.109375
13	.07196	.095	.0915	.092	.095	.09375
14	.06408	.083	.0800	.080	.083	.078125
15	.05707	.072	.0720	.072	.072	.0703125
16	.05082	.065	.0625	.064	.065	.0625
17	.04526	.058	.0540	.056	.058	.05625
18	.04030	.049	.0475	.048	.049	.05
19	.03589	.042	.0410	.040	.040	.04375
20	.03196	.035	.0348	.036	.035	.0375
21	.02846	.032	.0317	.032	.0315	.034275
22	.02535	.028	.0286	.028	.0295	.03125
23	.02257	.025	.0258	.024	.0270	.028125

The gauges shown above are used in various localities and industries, but to avoid misunderstanding it is desirable to express size in fractions (decimal or common) of an inch.

95 • COMPARISON OF GAUGES (Concl'd)

Gauge No.	American or Brown & Sharpe's	Birm'ghan or Stubs'	Washburn & Moen	Imperial (British) S. W. G.	London or Old English	United States Standard
24	.02010	.022	.0230	.022	.0250	.025
25	.01790	.020	.0204	.020	.0230	.021875
26	.01594	.018	.0181	.018	.0205	.01875
27	.01420	.016	.0173	.0164	.01875	.0171875
28	.01264	.014	.0162	.0148	.01650	.015625
29	.01126	.013	.0150	.0136	.01550	.0140625
30	.01003	.012	.0140	.0124	.01375	.0125
31	.008928	.010	.0132	.0116	.01225	.0109375
32	.007950	.009	.0128	.0108	.01125	.01015625
33	.007080	.008	.0118	.0100	.01025	.009375
34	.006305	.007	.0104	.0092	.00950	.00859375
35	.005615	.005	.0095	.0084	.00900	.0078125
36	.005000	.004	.0090	.0076	.00750	.00703125
37	.004453	....	.0085	.0068	.00650	.006640625
38	.003965	....	.0080	.0060	.00575	.00625
39	.003531	....	.0075	.0052	.00500	....
40	.003145	....	.0070	.0048	.00450	....
41	.002800	....	.0066	.0044	....	....
42	.002494	....	.0062	.0040	....	....
43	.002221	....	.0060	.0036	....	....
44	.001978	....	.0058	.0032	....	....
45	.001761	....	.0055	.0028	....	....
46	.001568	....	.0052	.0024	....	....
47	.001397	....	.0050	.0020	....	....
48	.001244	....	.0048	.0016	....	....
49	.001108	....	.0046	.0012	....	....
50	.0009863	....	.0044	.0010	....	....

The gauges shown above are used in various localities and industries, but to avoid misunderstanding it is desirable to express size in fractions (decimal or common) of an inch.

96 • DECIMAL EQUIVALENTS

1/64	.015625	33/64	.515625
1/32	.03125	17/32	.53125
3/64	.046875	35/64	.546875
1/16	.0625	9/16	.5625
5/64	.078125	37/64	.578125
3/32	.09375	19/32	.59375
7/64	.109375	39/64	.609375
1/8	.125	5/8	.625
9/64	.140625	41/64	.640625
5/32	.15625	21/32	.65625
11/64	.171875	43/64	.671875
3/16	.1875	11/16	.6875
13/64	.203125	45/64	.703125
7/32	.21875	23/32	.71875
15/64	.234375	47/64	.734375
1/4	.250	3/4	.750
17/64	.265625	49/64	.765625
9/32	.28125	25/32	.78125
19/64	.296875	51/64	.796875
5/16	.3125	13/16	.8125
21/64	.328125	53/64	.828125
11/32	.34375	27/32	.84375
23/64	.359375	55/64	.859375
3/8	.375	7/8	.875
25/64	.390625	57/64	.890625
13/32	.40625	29/32	.90625
27/64	.421875	59/64	.921875
7/16	.4375	15/16	.9375
27/64	.453125	61/64	.953125
15/32	.46875	31/32	.96875
31/64	.484375	63/64	.984375
1/2	.500	1	1.0000

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ARMY — Issued and used by the U. S. Army for material for which there is no Federal specification. Army specifications are usually cancelled when a Federal specification is issued for the same material.

NAVY — Issued and used by the U. S. Navy Department or by one of the Bureaus of the Navy. (See note under Federal specifications regarding use of Federal Specifications by the Bureau of Aeronautics of the Navy Department.) Individual Bureaus of the Navy Department may prepare Bureau specifications for materials which they require but which are not generally used by other Bureaus. Other Bureaus may use these specifications if they wish or may prepare their own specifications; however, if more than one Bureau uses the material a Navy Department specification is usually issued. When a Navy Department specification is revised, the Bureau responsible for its preparation usually issues an Interim (INT) Bureau specification which becomes applicable to contracts of that Bureau and may be used by other Bureaus during the time required for its approval and printing as the revised Navy Department specification. Since more than one issue of an Interim specification may be prepared, it is essential to observe the date of any Interim specification to which reference is made.

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S.A.E. — Issued by the Society of Automotive Engineers. The Handbook Standards are the alloys described in the S.A.E. Handbook and are not in the form of purchase specifications. The A.M.S. are purchase specifications prepared by the Aeronautical Material Specifications Subdivision. S.A.E. Aeronautical Material Specifications have been approved by the Army Air Forces and the Bureau of Aeronautics of the Navy Department for use by builders of aircraft engines.

A.S.T.M. — Issued by the American Society for Testing Materials.

related specifications*

97 • RELATED

ALLOY	PRODUCT	FEDERAL	ARMY AND ARMY AIR FORCES
2S	Plate and Sheet	QQ-A-561	....
	Bar, Rod, Wire, Shapes	QQ-A-411b	....
	Tubing, Round	WW-T-783a	....
	Rivets	....	....
	Rivet Wire	....	....
	Foil	....	....
	Corrugated Sheet	....	AAF-11077
3S	Plate and Sheet	QQ-A-359a	....
	Bar, Rod, Wire, Shapes	QQ-A-356b	....
	Tubing, Round	WW-T-788a	....
	Rivets	....	....
	Rivet Wire	....	....
11S	Bars and Rods	....	AXS-1318-R1 AAF-11330B
	Forgings	....	AXS-1524-R1
14S	Shapes (Extruded)	....	....
	Forgings	QQ-A-376b-1	....
	Forging Stock	....	....

* Always use latest revision of any specification indicated by a higher amendment number or suffix letter.

SPECIFICATIONS

NAVY	ARMY-NAVY (AN) AERONAUTICAL	SAE		ASTM
		HAND-BOOK	AMS	
47A2e	....	25	4001A 4003A	B25-44T B178-44T
46A3e	....	25	....	....
44T19c	....	25	4062A	....
....	AN-R-19-2	25	7220A	....
....	AN-QQ-W-298-3	25	....	....
47A5b	AN-A-20-1	....	....	....
....	....	....	....	....
47A4d	....	29	4006A 4008A	B79-44T B126-44T
46A6e	....	29	....	....
44T20b	....	....	....	....
43R5g	....	....	....	....
43R5g	....	....	....	....
....	....	....	....	....
....	....	....	....	....
....	AN-A-8	260	....	....
46A7e	....	260	4134 4135C	....
....	....	....	4134 4135C	....

related specifications*

98 • RELATED			
ALLOY	PRODUCT	FEDERAL	ARMY AND ARMY AIR FORCES
17S	Plate and Sheet	QQ-A-353a	....
	Bar, Rod, Wire, Shapes	QQ-A-351b	....
	Tubing, Round	WW-T-786a	....
	Tubing, Streamline	....	57-187-2B
	Forgings	QQ-A-367b-1	....
	Rivets	....	....
	Rivet Wire	....	....
	Corrugated Sheet	....	AAF-11077
Pureclad 17S	Plate and Sheet	QQ-A-361	....
A17S	Rivets	....	....
	Rivet Wire	....	....
18S	Forgings	QQ-A-367b-1	....
	Forging Stock	....	....
24S	Plate and Sheet	QQ-A-355a	....
	Bar, Rod, Wire, Shapes	QQ-A-354a	....
	Tubing, Round	WW-T-785	....
	Tubing, Streamline	....	....
	Rivets	....	....
	Rivet Wire	....	....
Pureclad 24S	Plate and Sheet	QQ-A-362	....

* Always use latest revision of any specification indicated by a higher amendment number or suffix letter.

SPECIFICATIONS

NAVY	ARMY-NAVY (AN) AERONAUTICAL	SAE HAND-BOOK	SAE AMS	ASTM
....	....	....	4030C 4032C	B78-44T
46A4g.	....	26	4118B 4151A	B89-44T
44T21e	....	....	....	....
....	....	....	....	....
46A7e	....	26	....	....
....	AN-R-19-2	26	....	....
....	AN-QQ-W-298-3	26	....	....
....	....	....	....	....
....	....	....	....	....
....	AN-R-19-2	....	7222A	....
....	AN-QQ-W-298-3	....	....	....
46A7e	....	270	4140C	....
....	....	....	4140C	....
47A10e	AN-A-12-1	24	4035B 4037B	....
46A9e	....	24	4120A 4152B	....
44T28b	AN-T-80	24	4088B	....
....	AN-T-80	24	....	....
....	AN-R-19-2	24	....	....
....	AN-QQ-W-298-3	24	....	....
....	AN-A-13-2	240	4040B 4041B 4042B	....

related specifications*

99 • RELATED			
ALLOY	PRODUCT	FEDERAL	ARMY AND ARMY AIR FORCES
25S	Forgings	QQ-A-367b-1	....
	Forging Stock	....	....
32S	Forgings	QQ-A-367b-1	....
	Forging Stock	....	....
A51S	Forgings	QQ-A-367b-1	....
	Forging Stock	....	....
52S	Plate and Sheet	QQ-A-318-a	....
	Bar, Rod, Wire, Shapes	QQ-A-315	....
	Tubing, Round	WW-T-787	57-187-3
56S	Bar, Rod, Wire	....	....
	Rivets	....	....
	Rivet Wire	....	....
75S	Plate and Sheet	....	....
	Bar, Rod, Wire, Shapes	....	AXS-1641
	Tubing, Round	....	....
	Forgings	....	....
	Forging Stock	....	....
Clad 75S	Plate and Sheet	....	AXS-1649

* Always use latest revision of any specification indicated by a higher amendment number or suffix letter.

SPECIFICATIONS

NAVY	ARMY-NAVY (AN) AERONAUTICAL	SAE HAND-BOOK	SAE AMS	ASTM
46A7e	....	27	4130C	....
....	....	....	4130C	....
46A7e	....	290	4145D	....
....	....	....	4145D	....
46A7e	....	280	4125C	....
....	....	....	4125C	....
47A11c	....	201	4015B 4016B 4017B	B109-44T
46A11a	....	201	....	....
....	....	201	4070C	....
A28a 15C1(INT)	See Par. E-36 AN-WW-C-561a-3	....	....	....
....	AN-R-19-2	....	....	....
....	AN-QQ-W-298-3	....	....	....
....	AN-A-9a	....	....	....
....	AN-A-11a	....	4122 4154	....
....	AN-T-32	....	....	....
....	....	....	4139	....
....	....	....	4139	....
....	AN-A-10b	....	....	....

related specifications*

100 • RELATED			
ALLOY	PRODUCT	FEDERAL	ARMY AND ARMY AIR FORCES
76S	Forgings	....	....
	Forging Stock	....	....
Hard Clad R301	Plate and Sheet	....	....
R303	Shapes (Extruded)	....	....
R317	Bars and Rods	....	AAF-11330B AXS-1651
R353	Plate and Sheet	QQ-A-334	....
	Bar, Rod, Wire, Shapes	QQ-A-331b	....
	Tubing, Round	WW-T-790	....
	Forgings	QQ-A-367b-1	....
	Rivets	....	....
	Rivet Wire	....	....
R361	Plate and Sheet	QQ-A-327	....
	Bar, Rod, Wire, Shapes	QQ-A-325	....
	Tubing, Round	WW-T-789	....
99.7%	Sheet	....	....
99.75%	Ingot	QQ-A-451a	....
99.5%	Ingot	QQ-A-451a	....
99.3%	Ingot	QQ-A-451a	....

* Always use latest revision of any specification indicated by a higher amendment number or suffix letter.

SPECIFICATIONS

NAVY	ARMY-NAVY (AN) AERONAUTICAL	SAE		ASTM
		HAND-BOOK	AMS	
....	....	....	4137	....
....	....	....	4137	....
....	AN-A-22	....	....	....
....	AN-A-37	....	....	....
....	....	....	....	....
....	....	....	....	....
....	....	282	....	....
....	....	....	4076B	....
46A7e	....	282	....	....
43R5g	....	282	....	....
43R5g	....	282	....	....
47A12b	....	281	4025A 4026A 4027A	....
46A10d	....	281	4150	....
44T30b	....	281	4080C 4082C	....
....	....	....	4000A	....
46A2c	....	....	....	....
46A2c	....	....	....	B24-44T
46A2c	....	....	....	....

related specifications*

101 • RELATED			
ALLOY	PRODUCT	FEDERAL	ARMY AND ARMY AIR FORCES
99.2%	Ingot	....	....
99%	Ingot	QQ-A-451a	....
98%	Ingot	QQ-A-451a	....
13	Foundry Ingot	....	....
43	Foundry Ingot	QQ-A-371a	....
85	Foundry Ingot	....	....
105	Foundry Ingot	....	....
108	Foundry Ingot	QQ-A-371a	....
A108	Foundry Ingot	....	....
113	Foundry Ingot	....	....
122	Foundry Ingot	QQ-A-371a	....
A132	Foundry Ingot	QQ-A-371a	....
142	Foundry Ingot	QQ-A-371a	....
195	Foundry Ingot	QQ-A-371a	....
B195	Foundry Ingot	....	....
212	Foundry Ingot	QQ-A-371a	....
214	Foundry Ingot	QQ-A-371a	....
355	Foundry Ingot	QQ-A-371a	....
A355	Foundry Ingot	QQ-A-371a	....
356	Foundry Ingot	QQ-A-371a	....
A380	Foundry Ingot	....	....

* Always use latest revision of any specification indicated by a higher amendment number or suffix letter.

SPECIFICATIONS

NAVY	ARMY-NAVY (AN) AERONAUTICAL	SAE HAND-BOOK	SAE AMS	ASTM
....	....	....	....	B24-44T
46A2c	....	....	....	B24-44T
46A2c	....	....	....	B24-44T
....	....	....	....	B125-44T
46A5e	....	....	....	B58-44T B112-44T B125-44T
....	....	....	....	B125-44T
46A5e	....	....	....	B58-44T
....	....	....	....	....
....	....	....	....	B112-44T
....	....	....	....	B58-44T
....	....	....	....	B58-44T B112-44T
....	....	....	....	B112-44T
....	....	....	....	B58-44T B112-44T
46A5e	....	....	....	B58-44T
....	....	....	....	B112-44T
....	....	....	....	....
46A5e	....	....	....	B58-44T
....	....	....	....	B58-44T
....	....	....	....	....
46A5e	....	....	....	B58-44T B112-44T
....	....	....	....	B125-44T

Effective packaging methods guard Reynolds products during shipment and storage

shrinkage allowances

103 • SAND CASTINGS, VARIOUS METALS	
METAL	CONTRACTION INCHES PER FOOT *
Aluminum Alloys	
Small castings of simple design	5/32
Larger castings or those of intricate design	1/8 to 1/12
Magnesium Alloys	5/32
Brass	3/16
Bronze	3/16
Gray Iron	1/10
Steel	1/4
Malleable Iron	1/8

*Shrinkage allowances for castings will vary according to the type of construction, casting dimensions and other factors peculiar to the particular material involved. If maintenance of very exact dimensions is required, the foundry which is to produce the castings should be consulted for shrinkage allowance recommendations before the pattern is made.

relative weights

104 • EQUAL VOLUMES, VARIOUS METALS	
METAL	RELATIVE WEIGHT
Magnesium	0.644
Aluminum, Commercially Pure	1.000
Zinc	2.65
Cast Iron (Gray)	2.65
Tin	2.71
Cast Steel	2.90
Cast Brass (60% Cu-40% Zn)	3.09
Cast Bronze (90% Cu-10% Sn)	3.26
Nickel	3.30
Copper	3.31
Lead	4.20

principal characteristics

105 • WROUGHT ALUMINUM ALLOY SHEET	
ALLOY	**CHARACTERISTICS**
2S	Low mechanical properties. Excellent drawing and forming properties. Excellent resistance to corrosion.
3S	Slightly stronger than 2S. Very good drawing and forming properties. Excellent resistance to corrosion.
52S	Medium mechanical properties. Good forming and drawing properties. Excellent resistance to corrosion in sea water.
17S	Ages at room temperature. Good formability. A high-strength alloy. Good resistance to most type of corrosion.
24S	Ages at room temperature. Has higher strengths than 17S with comparable workability and resistance to corrosion.
53S	Medium mechanical properties. Very good forming characteristics. Excellent resistance to all types of corrosion.
61S	Medium physical properties. Forming characteristics slightly superior to 53S. Excellent resistance to corrosion.
R301	Clad material. Mechanical properties comparable to 14S. Corrosion resistance comparable to 61S. Good forming characteristics.
R303	Excellent mechanical properties. Formability inferior to 24S. Excellent resistance to all types of corrosion.

106 • ALUMINUM FORGING ALLOYS

ALLOY	CHARACTERISTICS
A51S	Excellent forging characteristics. Higher yield strengths than 25S or 17S. Corrosion resistance comparable to 17S.
70S	Excellent forging characteristics. For intricate contours. Flows more easily than 25S. Fills radial concavities.
25S	Good forging properties. Mechanical properties comparable to 17S but more easily forged. Corrosion resistance inferior to 17S.
17S	Machinability better than 25S. High mechanical properties. Good corrosion resistance. Forging flow resistance high.
14S	Extremely high mechanical properties and hardness. Corrosion resistance comparable to 17S. "W" mechanical properties comparable to 17S-T.
18S	Good performance at elevated temperatures, such as those encountered in piston and engine parts.
32S	Low coefficient of expansion. Good corrosion resistance. Excellent performance at elevated temperatures.
53S	Possess medium mechanical properties. Used where maximum resistance to all types of corrosion is required.
R303	High mechanical properties. Excellent resistance to corrosion. Slightly harder to forge than 14S.

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sheet and plate

LIST OF TABLES

LIST OF TABLES

FIELD SERVICE OFFICES

City:	Address:	Phone:
Akron 8, Ohio	307 Builders Center Bldg.	Hemlock 4178
Atlanta 3, Ga.	616 Bona-Allen Bldg.	Jackson 4566
Baltimore 2, Md.	1132 Baltimore Trust Bldg.	Lexington 3010
Birmingham 3, Ala.	702 Watts Bldg.	Birmingham 4-6884
Boston 16, Mass.	441 Park Square Bldg.	Liberty 0655
Buffalo 3, N. Y.	1116 Rand Bldg.	Washington 2606
Chicago, 11, Ill.	1004 Wrigley Bldg.	Whitehall 2200
Cincinnati 2, Ohio	4017 Carew Tower	Main 2125
Cleveland 15, Ohio	310 Hanna Bldg.	Cherry 7214-5
Dallas 1, Texas	1806 Mercantile Bank Bldg.	Riverside 3429
Dayton 2, Ohio	215 Talbott Bldg.	Hemlock 5923
Denver 6, Colo.	380 Gaylord St.	East 6727
Detroit 2, Mich.	1010 Fisher Bldg.	Trinity 1-8800
Grand Rapids 2, Mich.	719 Commerce Bldg.	Grand Rapids 9-6280
Indianapolis 4, Ind.	280 Century Bldg.	Franklin 9459
Kansas City 6, Mo.	617 Dwight Bldg.	Victor 2696-7
Los Angeles 14, Calif.	1709 West Eighth St.	Drexel 8311
Louisville 1, Ky.	2500 South Third St.	Magnolia 4760
Milwaukee 3, Wis.	1412 Majestic Bldg.	Marquette 1051
Minneapolis 2, Minn.	1150 Northwestern Bk. Bldg.	Bridgeport 6843
Moline, Ill.	603 State Trust Bldg.	Moline 178
New Orleans 12, La.	1014 Canal Bank Bldg.	Raymond 4258-9
New York 17, N. Y.	19 East 47th St.	Eldorado 5-7700
Philadelphia 3, Pa.	1600 Arch St.	Rittenhouse 4300
Pittsburgh 19, Pa.	504 Grant Bldg.	Atlantic 7888
Portland 5, Oregon	407 New Fleidner Bldg.	Beacon 5312
St. Louis 2, Mo.	1209 Landreth Bldg.	Chestnut 4861-2
San Francisco 3, Cal.	345 Ninth St.	Hemlock 6130
Seattle 1, Wash.	826 Henry Bldg.	Seneca 2777
Tampa 2, Fla.	522 Stovall Prof. Bldg.	M-1468
Washington 5, D. C.	200 Southern Bldg.	National 5337
Wichita 2, Kansas	304 Wheeler-Kelly-Hagny Bldg.	Wichita 4-5976

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